GULFSTREAM G450
MAINTENANCE TRAINING MANUAL
ATA 32: LANDING GEAR

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FlightSafety International, Inc.
Marine Air Terminal, LaGuardia Airport
Flushing, New York 11371
(718) 565-4100
www.FlightSafety.com

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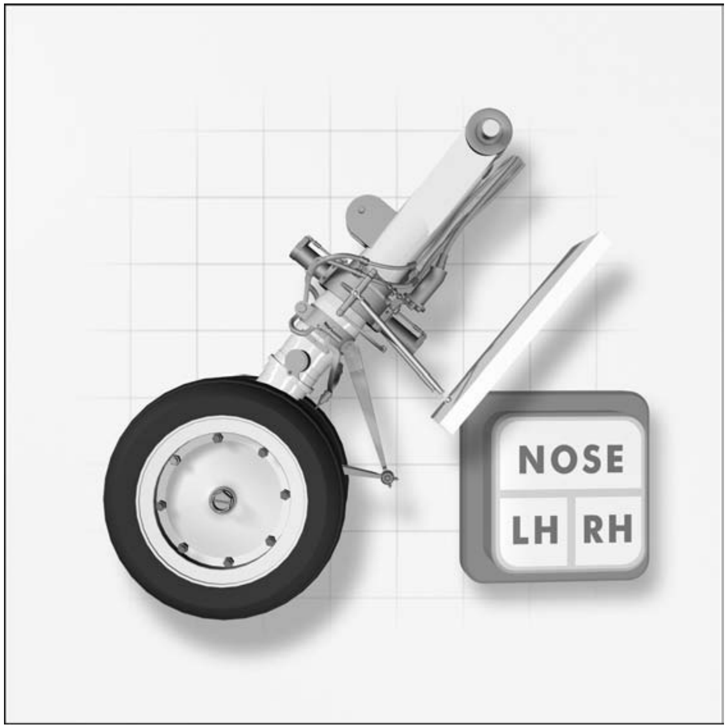
CHAPTER 32
LANDING GEAR



INTRODUCTION

This chapter presents an overview of the Gulfstream G350 / G450 aircraft landing gear. All values, such as for pressures, temperatures, rpm, and power, are used for their illustrative meanings only. The current manufacturer's *Maintenance Manual* must be consulted for all maintenance specifications and tolerances, and the actual values must be determined from the approved Gulfstream reference material.

Figure 32-1. Landing Gear

GENERAL

The aircraft has a fully retractricycle landing gear which consists of two main landing gears, located in each fuselage wing root area, and a dual-wheel nose landing gear in the forward section of the fuselage (Figure 32-1). The landing gear provides support of the aircraft and absorbs energy from landing, takeoff, and taxiing. Individual wheel braking with antiskid protection is provided for each of the main wheels.

The main and nose gears incorporate conventional oleopneumatic shock struts. The nosewheel steering unit can be disconnected manually, without the use of tools, for towing purposes. The landing gear is primarily manufactured from high-strength steel and aluminum materials. The struts are designed to be highly efficient for absorbing the aircraft's kinetic energy under dynamic load conditions.

They provide energy dissipation with controlled rebound characteristics. The shock strut internal design includes a metering pin and orifice which causes a restriction of fluid flow. This restriction creates back pressure which regulates the rate of compression.

The landing gear system is electrically controlled and hydraulically actuated. Retraction or extension of the landing gear is normally accomplished by the left hydraulic system. If the left system engine-driven pump fails (or if the left engine is shut down), the gear may be operated normally by utilizing the Power Transfer Unit (PTU). The auxiliary hydraulic system pressure can be utilized on the ground only to operate the landing gear through the ground service valve located next to the right side of the nose landing gear. The gear may also be extended through use of the emergency gear extension system, which supplies pneumatic pressure to extend the gear. Landing gear position indicators and an audible warning system are incorporated to provide positive indication and position of the landing gear. A weight-on-wheels (squat switch/ nutcracker) system is also included in the landing gear system to supply "ground" or "air" mode reference signals to various aircraft systems. Each gear shock strut is serviced with MIL-H-5606 hydraulic fluid.

Each gear incorporates three hydraulic actuators:

- A side brace actuator or nose landing gear actuator for retraction / extension
- An uplock actuator for locking and releasing the gear
- A door actuator for door opening and closing

A door control valve and two timer valves, per gear sequence the door and landing gear operation. In addition, the nose gear has a downlock actuator to control the positive locking feature of the truss brace assembly.

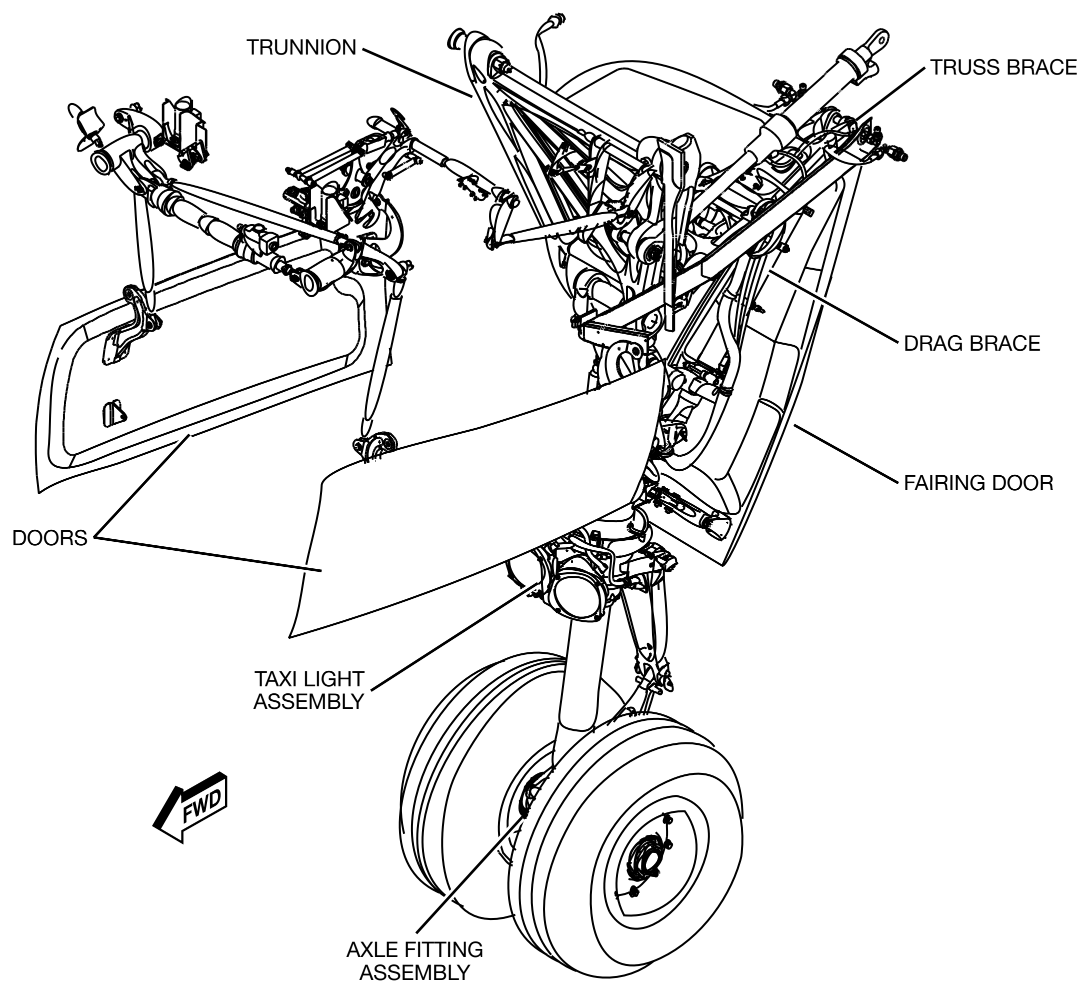


Figure 32-2. Nose Landing Gear

LANDING GEAR SAFETY DEVICES

To prevent the landing gear from collapsing in the event of failure or malfunction of the downlock mechanisms, a safety lock is provided for each of the main struts and the nose strut on all Gulfstream aircraft. These locks must be manually installed while the aircraft is on the ground and must be removed before flight if the gear is to be retracted.

The main gear ground lock is a pip pin and is placed in the lower end of the side brace-retraction actuator. The pip pin prevents the internal locking feature of the actuator from unlocking. The nose landing gear downlock pin is installed in the linkage aft of the nose gear strut, preventing the nose downlock actuator from retracting the nose gear downlock. Both main and nose gear ground lockpins are designed to withstand full system retraction pressure.

Additionally for the nose wheel well, a hold-open safety rod prevents closing of the nose gear doors even when the door control pin is installed.

LANDING GEAR SYSTEM

NOSE LANDING GEAR SYSTEM DESCRIPTION

The nose landing gear consists of a separate trunnion supporting a cantilever oleopneumatic shock strut with dual wheels (Figure 32-2). Further support is gained by a drag brace, which is attached to the lower end of the strut outer cylinder and to the fuselage at the aft end of the wheel well. The trunnion is mounted to the fuselage on a pivot axis that permits retraction of the nosewheels and strut, forward and up into the nose wheel well. Extension is aft and down.

The strut is locked in the extended position by a folding truss brace with a spring-loaded mechanical overcenter linkage. Internal centering cams are incorporated in the shock strut to center the nosewheels and retain the wheels in the neutral position during extension or retraction or at any other time the strut is fully extended with no weight on wheels. A combination rotary steering unit and shimmy damper is mounted to the strut outer cylinder concentrically and attached to the swiveling piston through a pair of torque arm scissors.

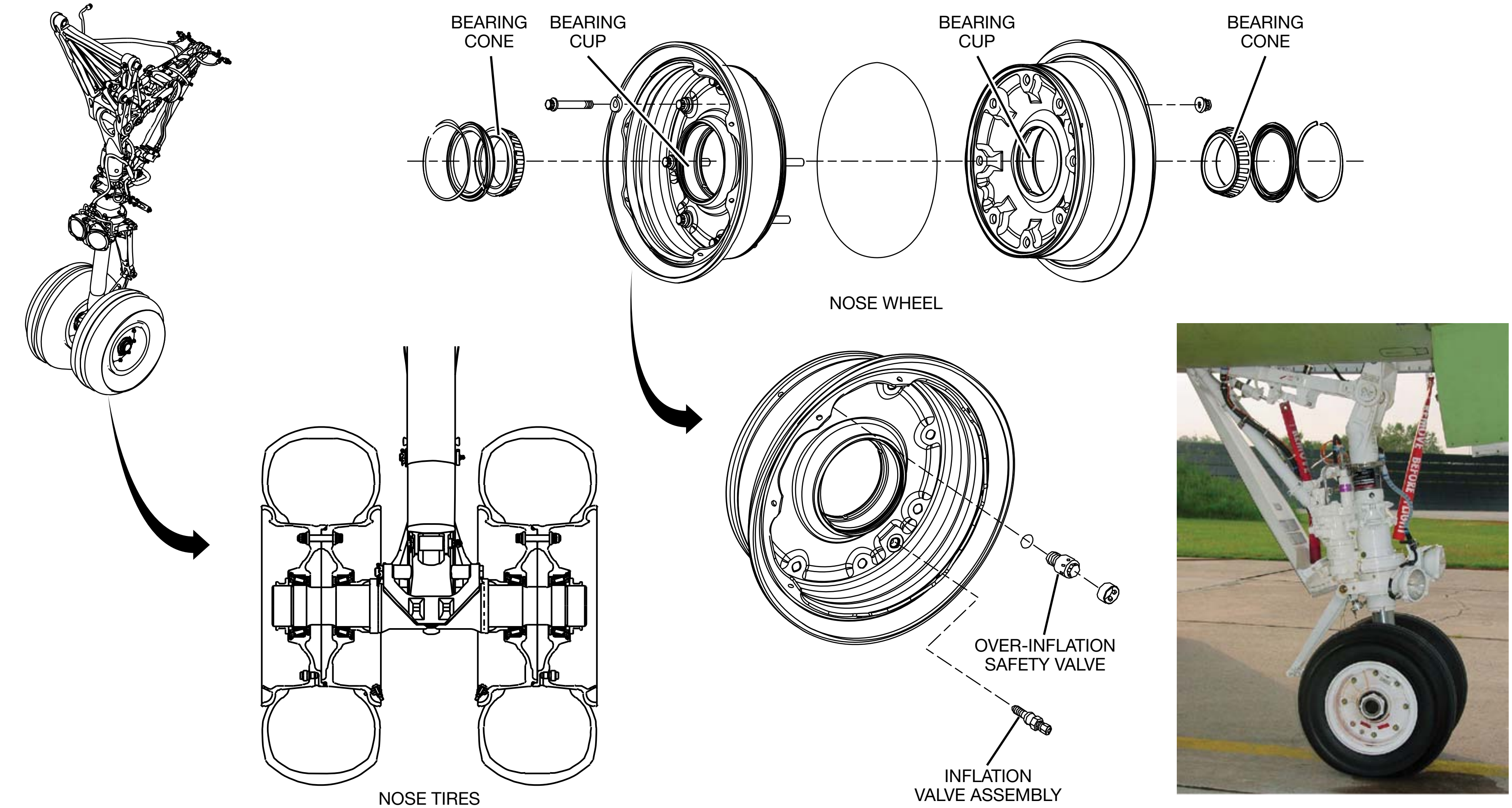


Figure 32-3. Nose Wheel and Tires

NOSE LANDING GEAR SYSTEM COMPONENTS

Nose Landing Gear

Nose Landing Gear Wheel and Tire

The two nosewheels each consist of two half-hubs bolted together to provide for tire mounting and inflation (Figure 32-3). The wheel and tire provide structural support for the aircraft's nose weight. The nose landing gear uses a 21X7.25-10 12 PLY tire. The tire is speed-rated to 225 mph and weights 20 pounds. An over-inflation safety valve is installed on each wheel and will release tire pressures between 300–350 psi.

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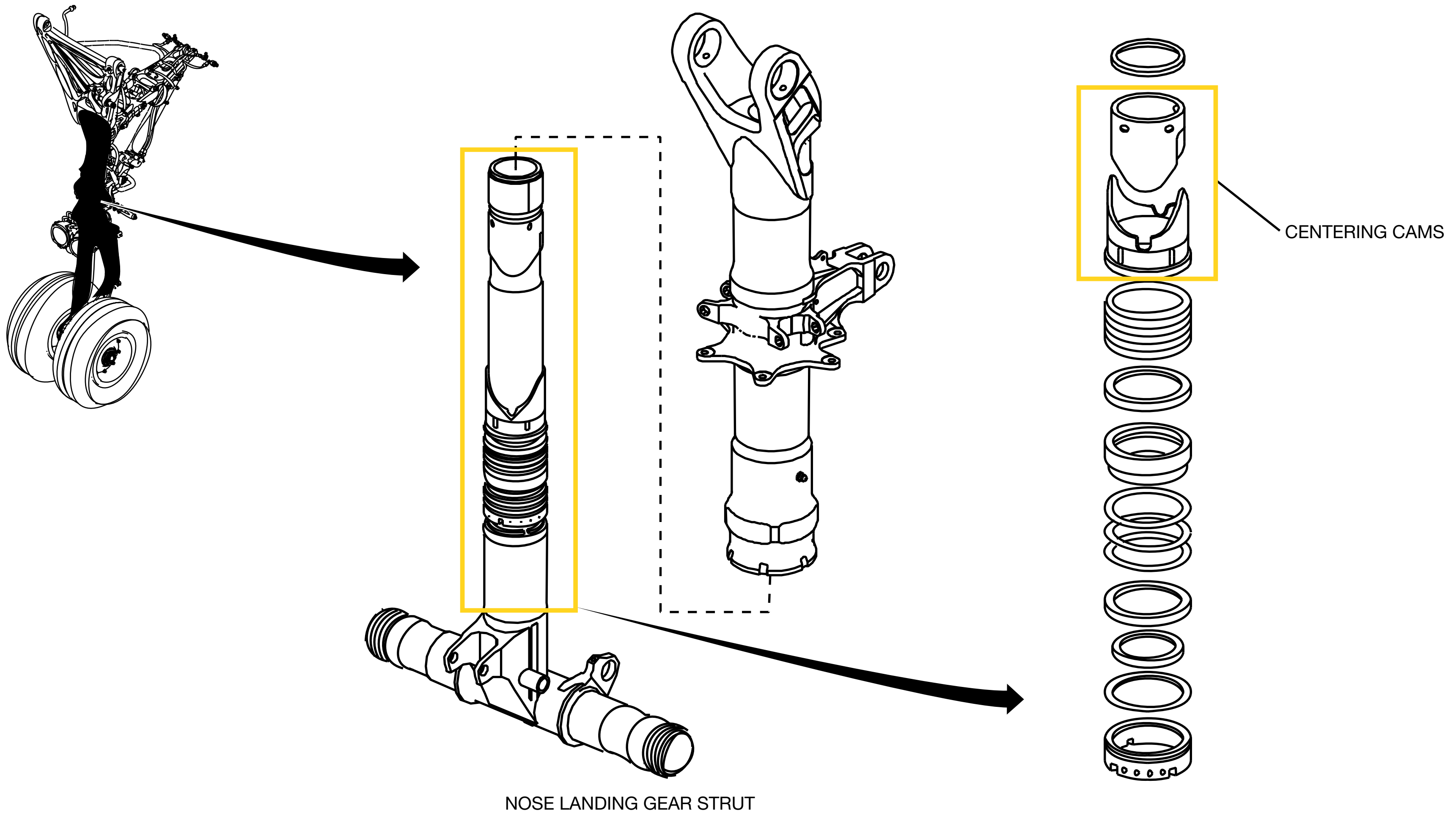

Figure 32-4. Nose Gear Centering Cams

Nose Landing Gear Strut

The strut is a conventional cantilevered nitrogen hydraulic unit weighting 148 lbs with a dual-wheel axle and is designed to absorb the shock of taxiing, takeoff and landing. It is essentially a steel piston riding in a cylinder, which utilizes ring seals to prevent fluid leakage. The strut assembly utilizes two internal cams that operate as centering components (Figure 32-4). An air / oil filler valve is provided at the top of the shock strut for servicing. A placard attached to the forward side of the trunnion (above the strut), or attached to the upper portion of the strut, indicates the correct strut extensions for given strut pressures. The shock strut (compressed) is filled to overflowing with MIL-L-5606 hydraulic fluid and pressurized with dry nitrogen to the correct specifications. The wheel axle fitting and the bottom of the strut piston are a single forged assembly. The nose gear strut provides mounting provisions for the steering actuator, taxi lights, hydraulic lines, wiring harnesses, two nosewheels, tires, tiedown rings, and a stowed jack pad.

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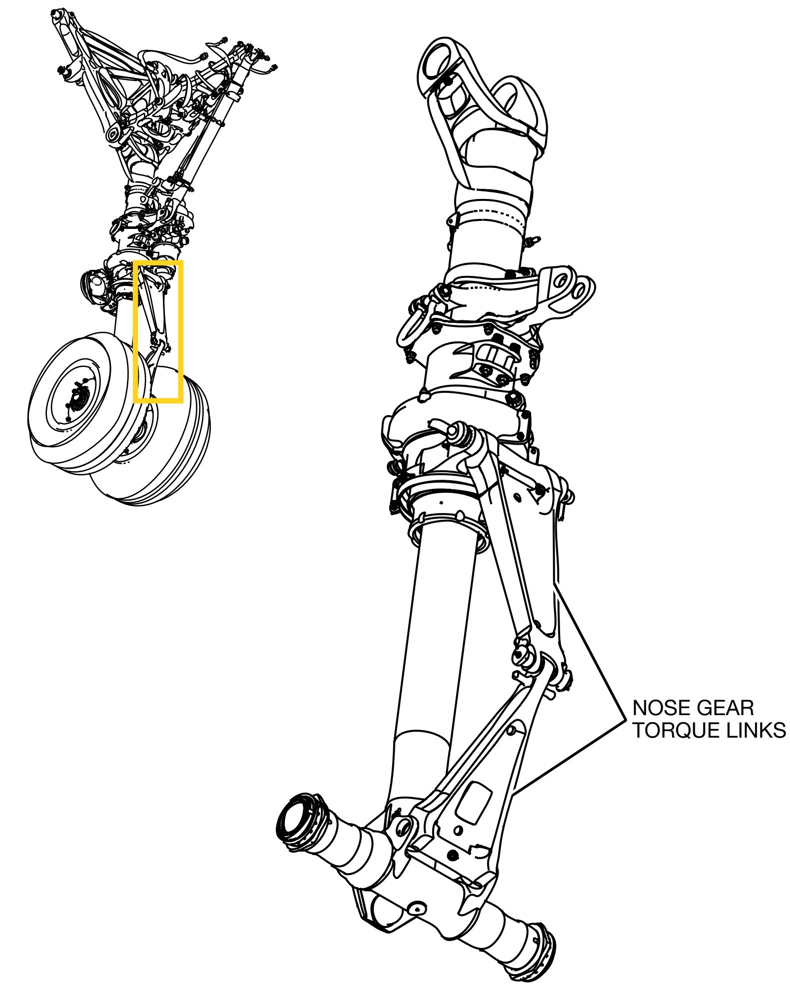

TORQUE LINKS CONNECTED

TORQUE LINKS DISCONNECTED

Figure 32-5. Nose Gear Torque Links

Torque Links

The nose landing gear torque links provide a connection for the nosewheel steering mechanical input. The torque links can be disconnected for towing, which allows 360° rotation when the strut is compressed (Figure 32-5). Extension of the lower strut more than 13.5 inches will engage the mechanical centering cams, possibly causing internal damage to the cams.

CAUTION

Nosewheel steering upper torque arm assembly must be disconnected prior to towing aircraft. Rotation of nosewheel beyond normal limits of travel (82°) can cause serious damage to steering unit. With steering unit torque links disconnected, nose wheels are free to rotate 360°.

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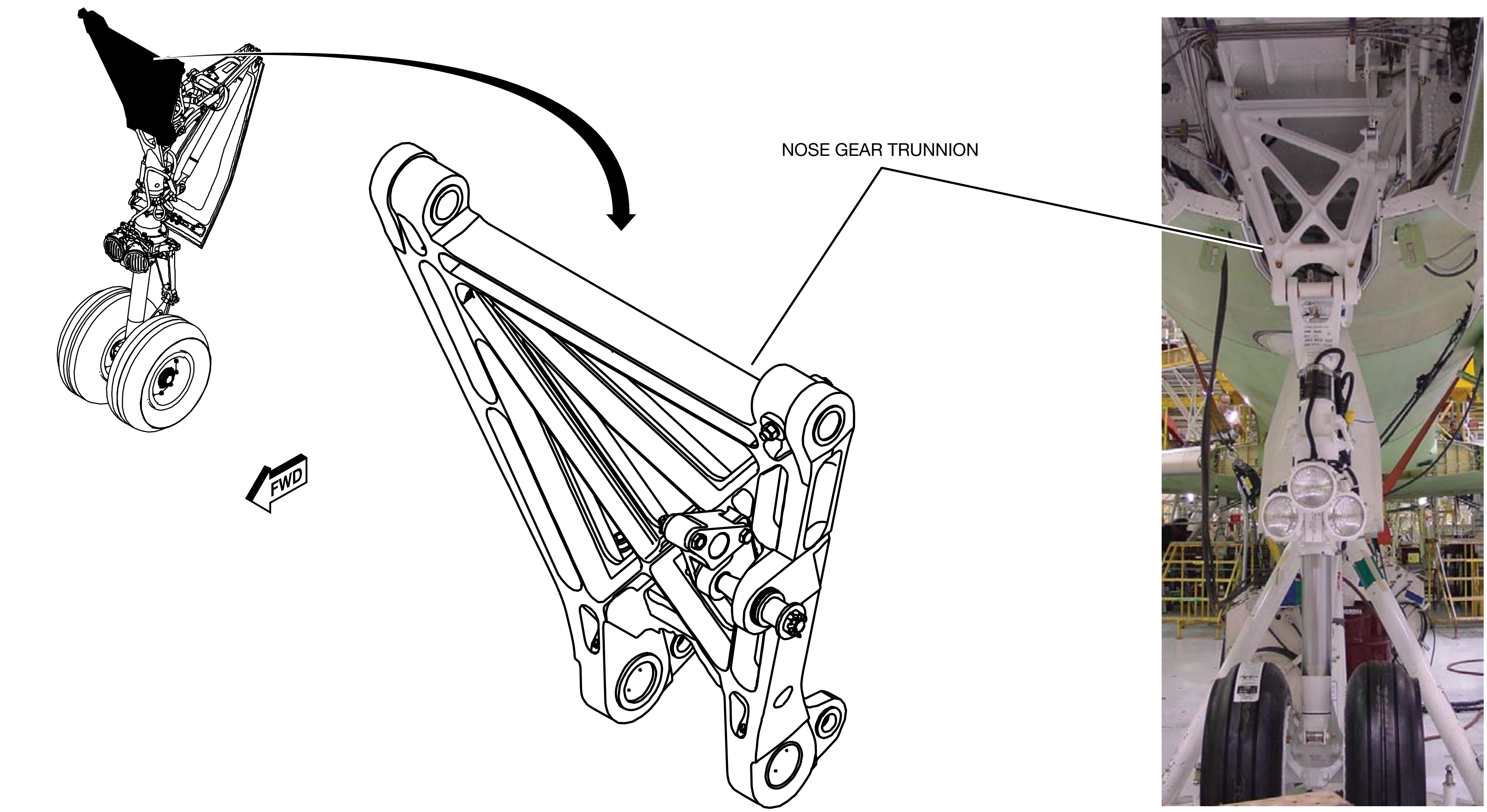

Figure 32-6. Nose Gear Trunnion

Trunnions

The nose landing gear trunnions are a truss design that connects the strut assembly to the fuselage (Figure 32-6). They provide attachment for the landing gear actuator, door control sequence linkage, and overcenter downlock mechanism.

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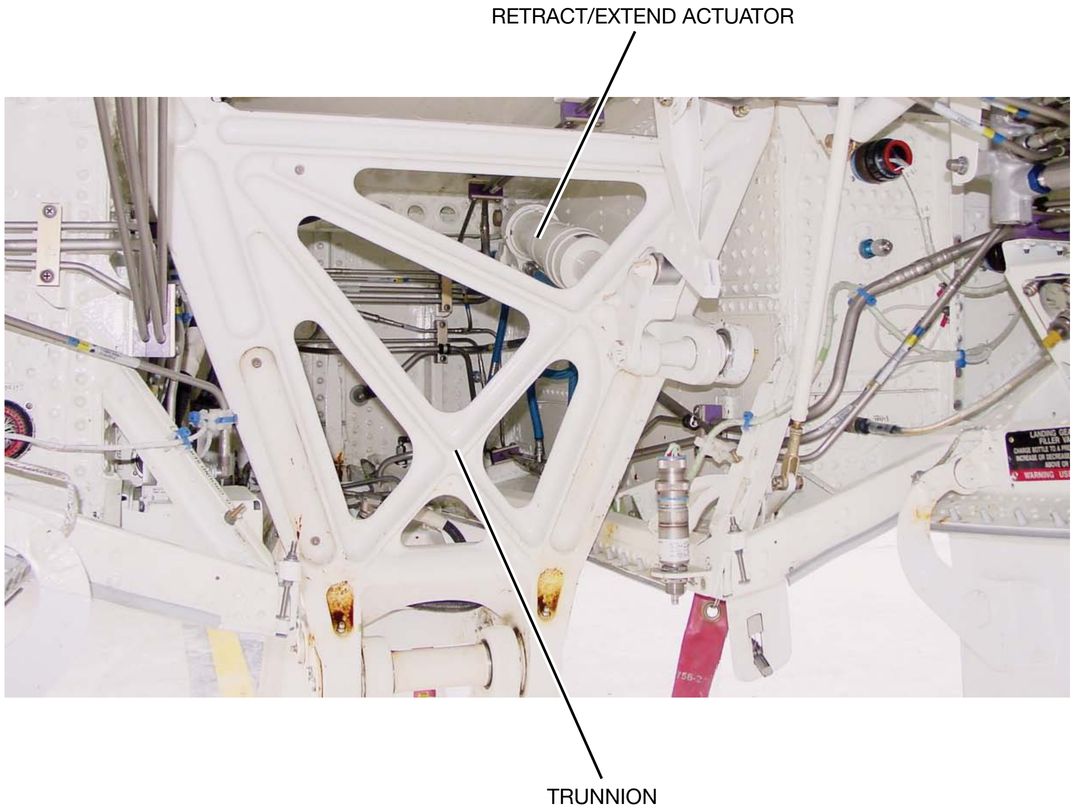

Figure 32-7. Nose Gear Retract/Extend Actuator

Nose Gear Retract/Extend Acutator

The landing gear extension and retraction system provides normal landing gear extension,retraction and emergency landing gear extension. It is hydraulically extended and retracted. In the event hydraulic pressure is not available to extend the landing gear, an emergency landing gear extension system can be used to lower the landing gear one time. The emergency extension system provides nitrogen pressurization of the landing gear for extension (Figure 32-7).

The nose landing gear hydraulic actuator is connected to the trunnion and the airframe. It extends and retracts the nose landing gear.

- After the landing gear has retracted, the landing gear components are positioned as follows:
- Nose landing gear and side brace actuators are unpressurized in the retracted position
- Doors are closed and locked with door actuators pressurized in the fully extended position
- Uplock actuator is pressurized in the retracted position

After the landing gear has extended, the landing gear components are positioned as follows:

- Nose landing gear and side brace actuators are pressurized and locked in the extended position
- Doors are closed with door actuators pressurized in the fully extended position
- Landing gear uplock actuators are unpressurized in the fully retracted position

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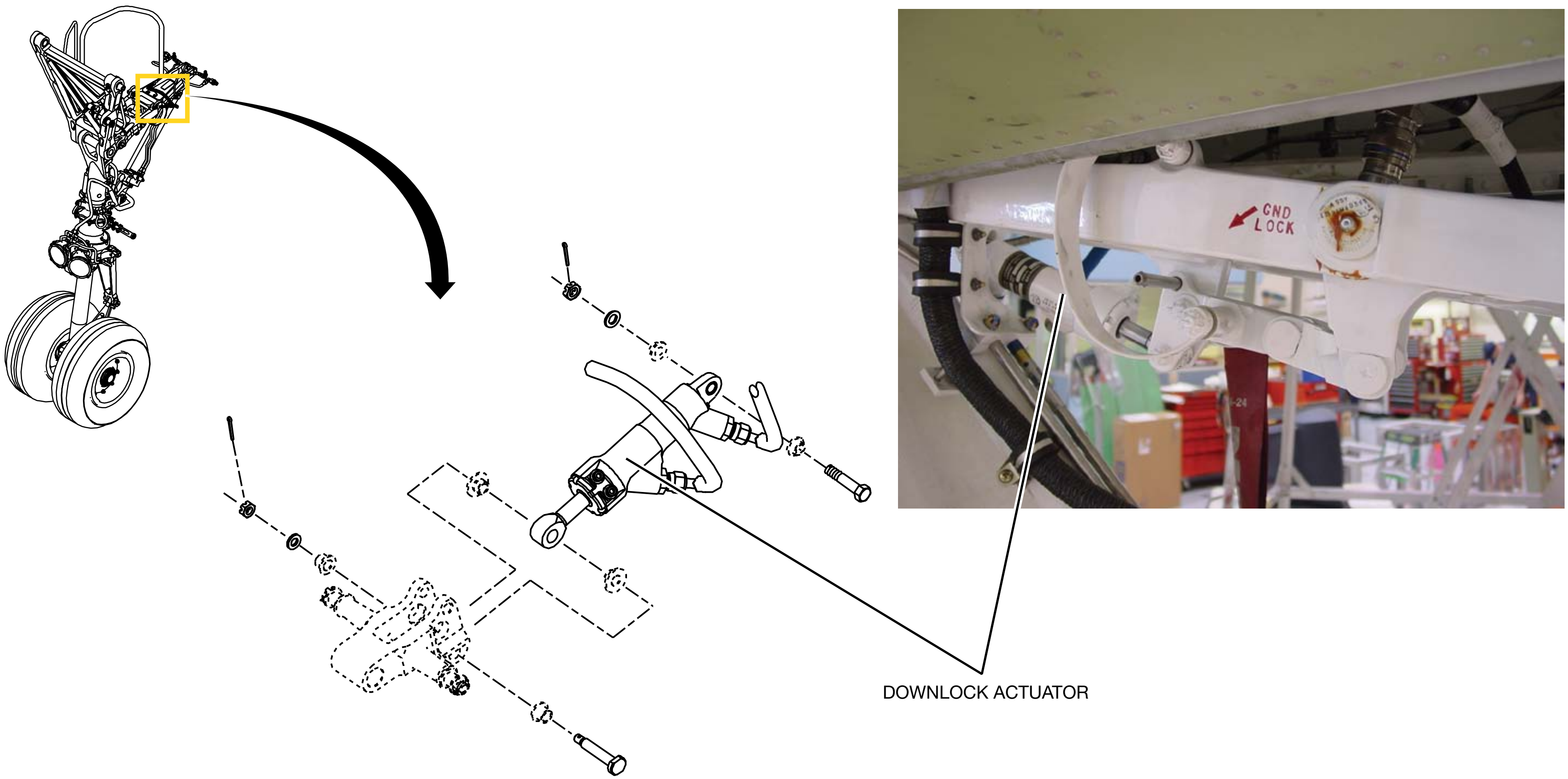

Figure 32-8. Nose Gear Downlock Actuator and Mechanism

Downlock Mechanism

The nose gear downlock mechanism consists of a folding forward and aft truss brace which incorporates a downlock switch, spring-loaded overcenter linkage, suitcase-type springs, and a hydraulic downlock actuator (Figure 32-8). The forward and aft truss braces provide the support which locks the nose landing gear in the extended position. The overcenter linkage is unlocked from the overcenter position by the hydraulic downlock actuator during retraction.

When hydraulic power is not applied to the downlock actuator, the overcenter linkage is maintained overcenter by the suitcase-type springs. The linkage is locked approximately .050-inch overcenter. During ground operations the downlock safety pin must be installed in the overcenter linkage to prevent inadvertent collapse of the nose gear.

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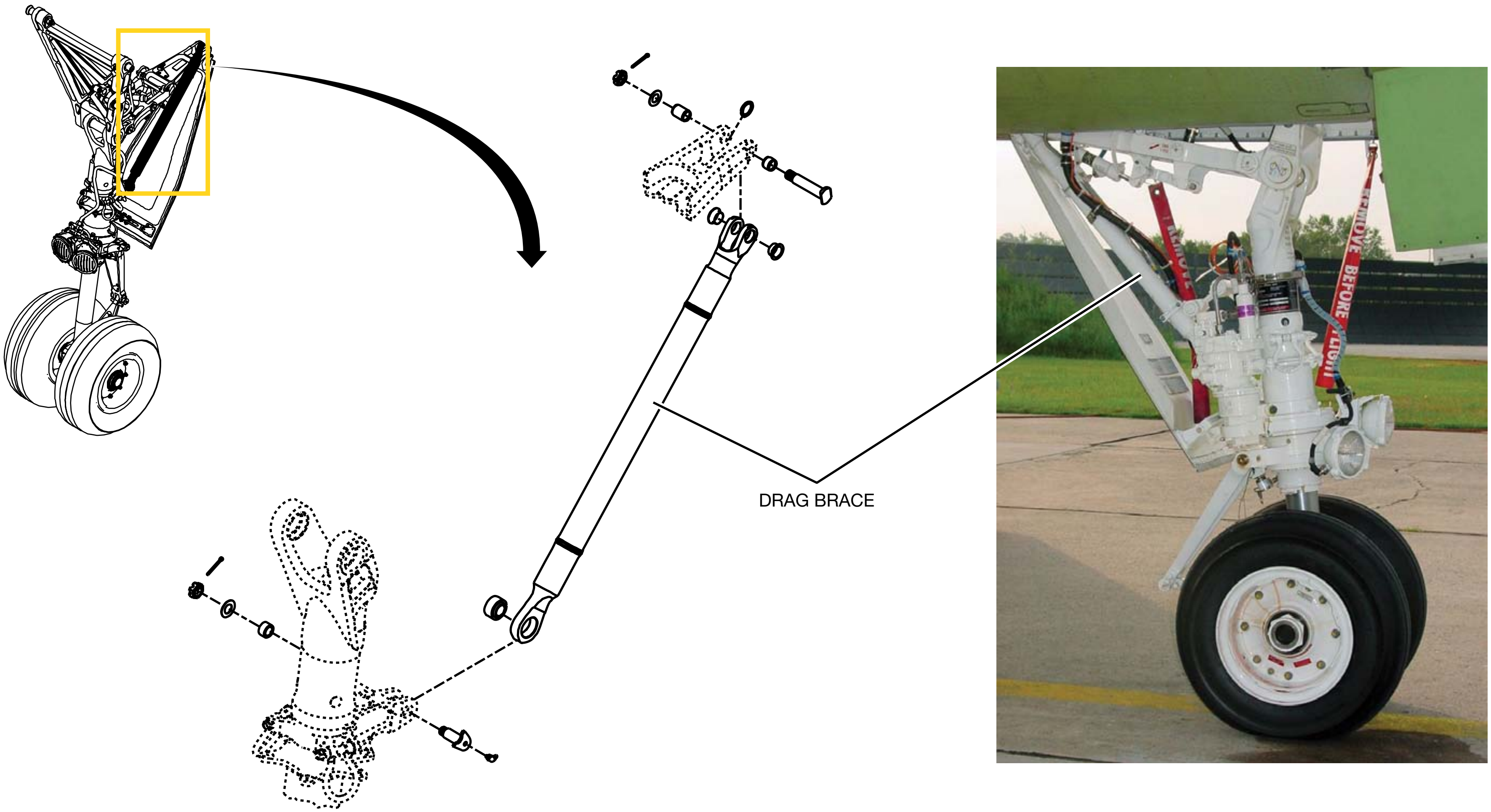

Figure 32-9. Drag Brace

Drag Brace

The nose landing gear drag brace provides additional support and is attached to the fuselage structure at the aft end of the nose wheel well and nose landing gear strut (Figure 32-9). The drag brace forces the nose landing gear up and forward during retraction.

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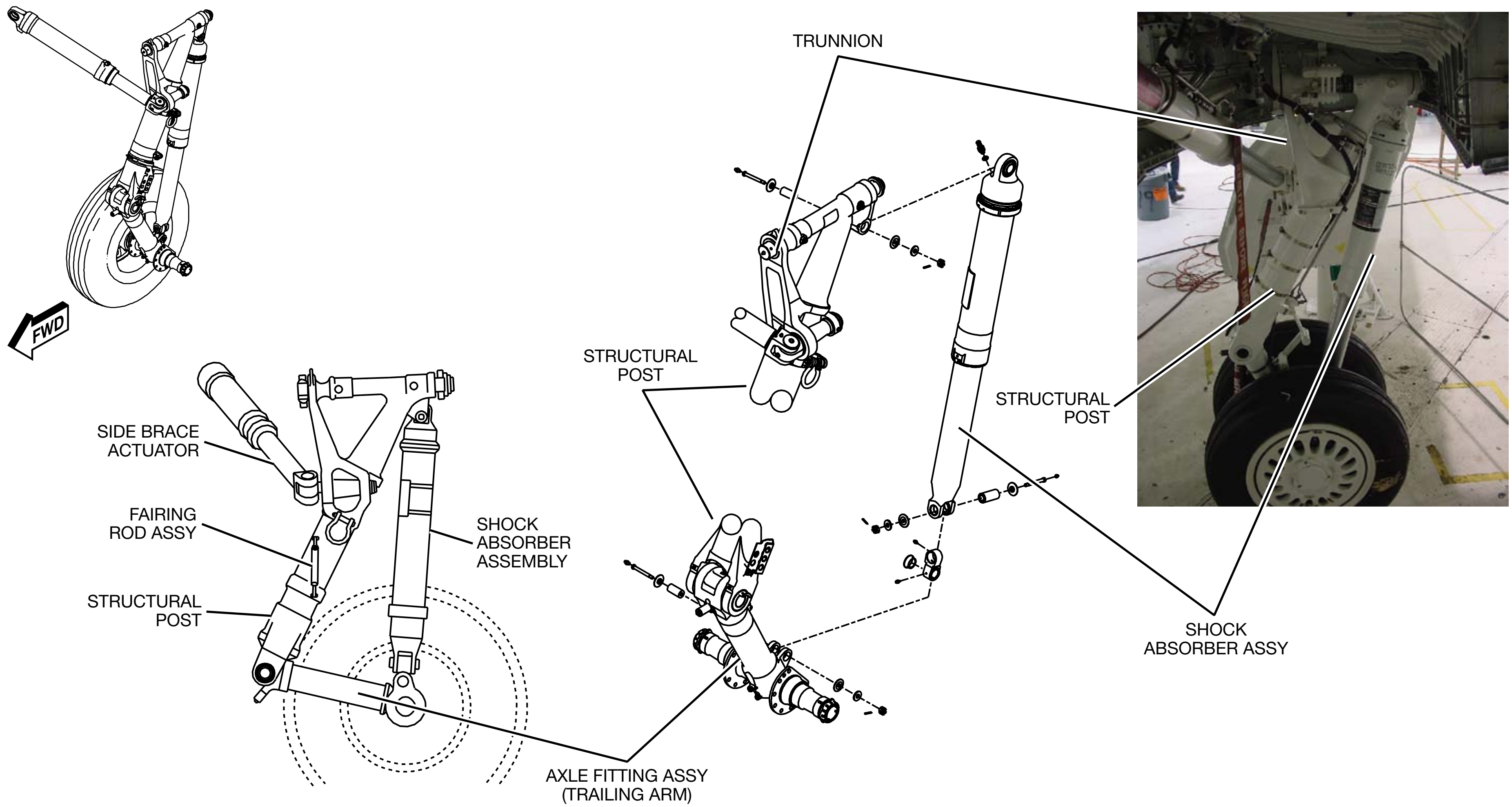

Figure 32-10. Landing Gear Structural Post

Main Landing Gear

Structural Post and Trunnion

The main landing gear structural post and trunnion are attached with two trunnion pins to the airframe at the wing trunnion mount (Figure 32-10). The structural post and trunnion provide mounting for the mooring ring, trailing arm pivot, main landing gear fairing door, main landing gear shock strut cylinder, wire harness, and hydraulic lines.

Trailing Arm

The main landing gear trailing arm provides pivot and attachment to the structural post, main landing gear axles, brake mounts, lower attachment for the main landing gear shock strut, and main landing gear jack pad adapter attach point.

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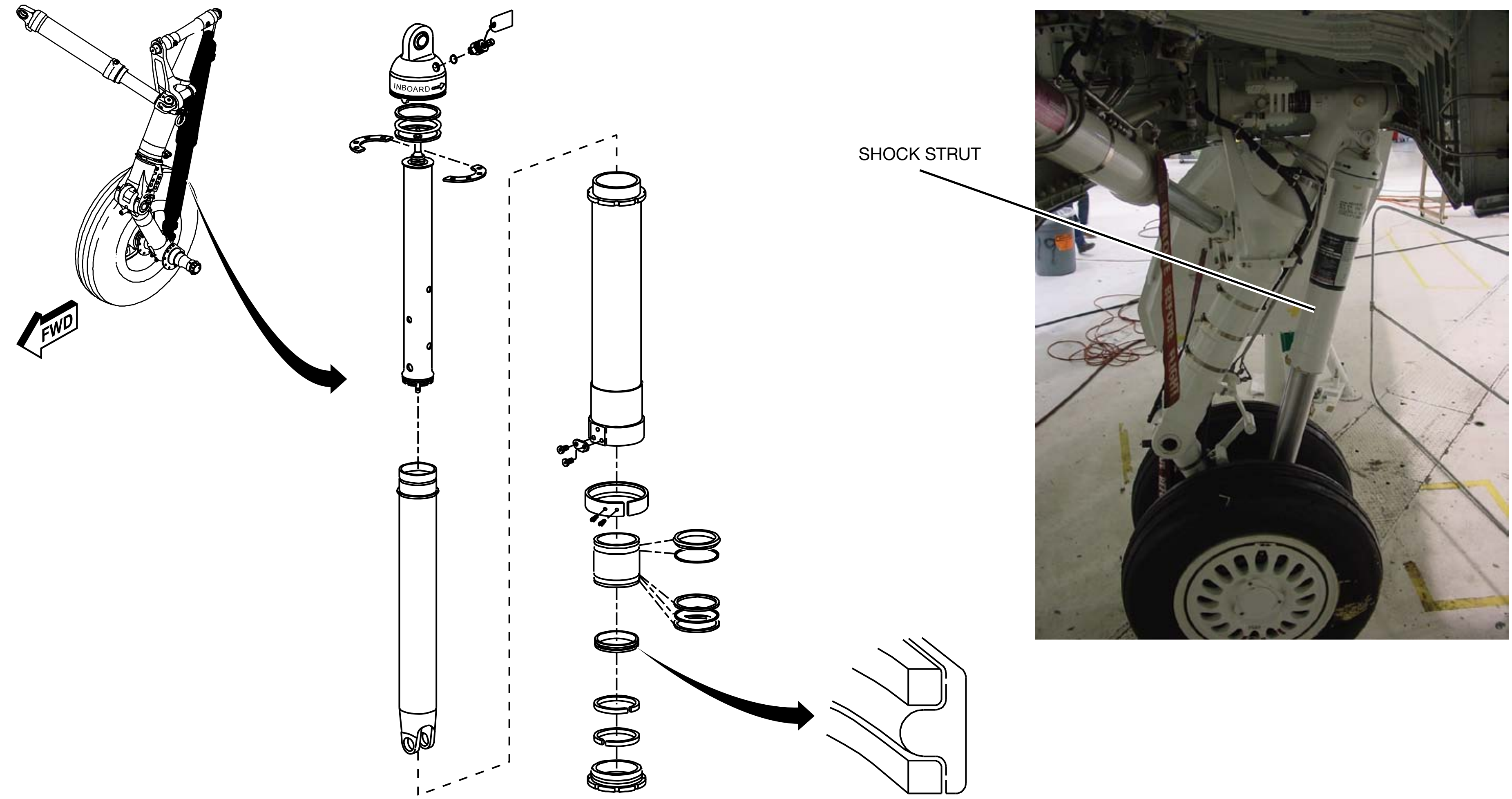

Figure 32-11. Main Landing Gear Strut—Internal

Strut Assembly

Each shock strut is a conventional nitrogen-hydraulic unit designed to absorb the shock of taxiing, takeoff, and landing. It is essentially a steel piston riding in a cylinder and utilizing ring seals to prevent fluid leakage between the piston and the outer cylinder. It is mounted on the upper aft side of the structural post and attaches to the axle fitting assembly (trailing arm) (Figure 32-11).

An air / oil filler valve is provided at the top of the shock strut and is used for strut servicing. The strut also includes a placard which indicates the correct strut extension for given strut pressures. The shock strut, when compressed, is filled to overflowing with MIL-H-5606 hydraulic fluid and is pressurized with dry nitrogen to proper extension.

NOTE

A felt wiper is installed at the base of the shock strut and must be lubricated with MIL-H-5606.

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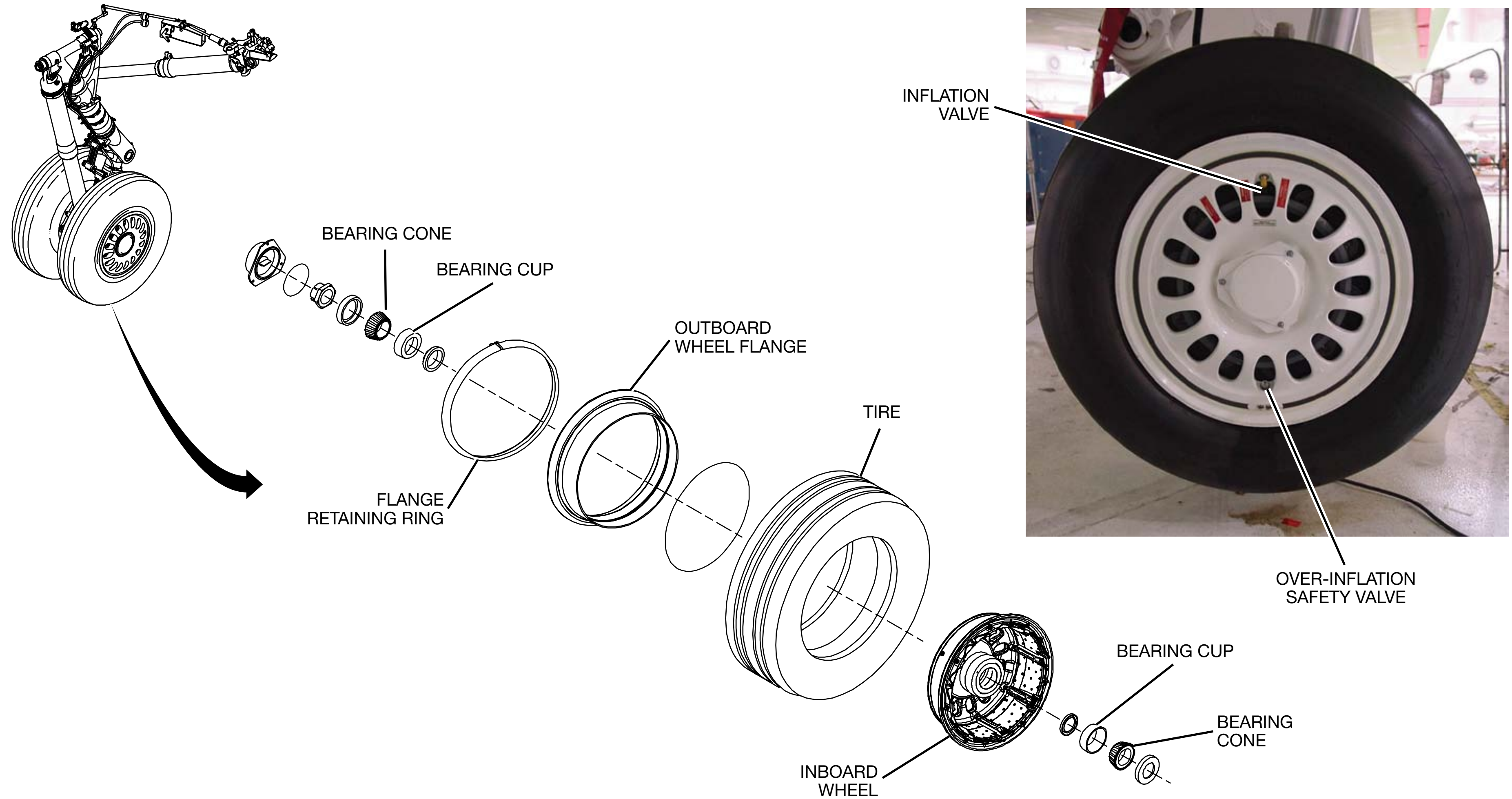

Figure 32-12. Main Wheel and Tire

Main Landing Gear Wheel and Tire

The main wheel consists of a hub and flange arrangement weighing 83 pounds (Figure 32-12). The flange width is 7 inches, and the heat shield is a single-skin type. There are four fusible plug assemblies and one over-inflation safety plug installed per wheel. The fusible plugs melt, releasing tire pressure at approximately 390°F (199°C), and the over-inflation safety plug activates at 412.25 ± 37.5 psi. The main landing gear is fitted with a size H34X9.25-18 18 PR tire and is designed to provide takeoff and landing cushioning and support and to assist ground handling capabilities. The tire is rated to 225 mph, weights 62 pounds, and is designed for up to 200 landings.

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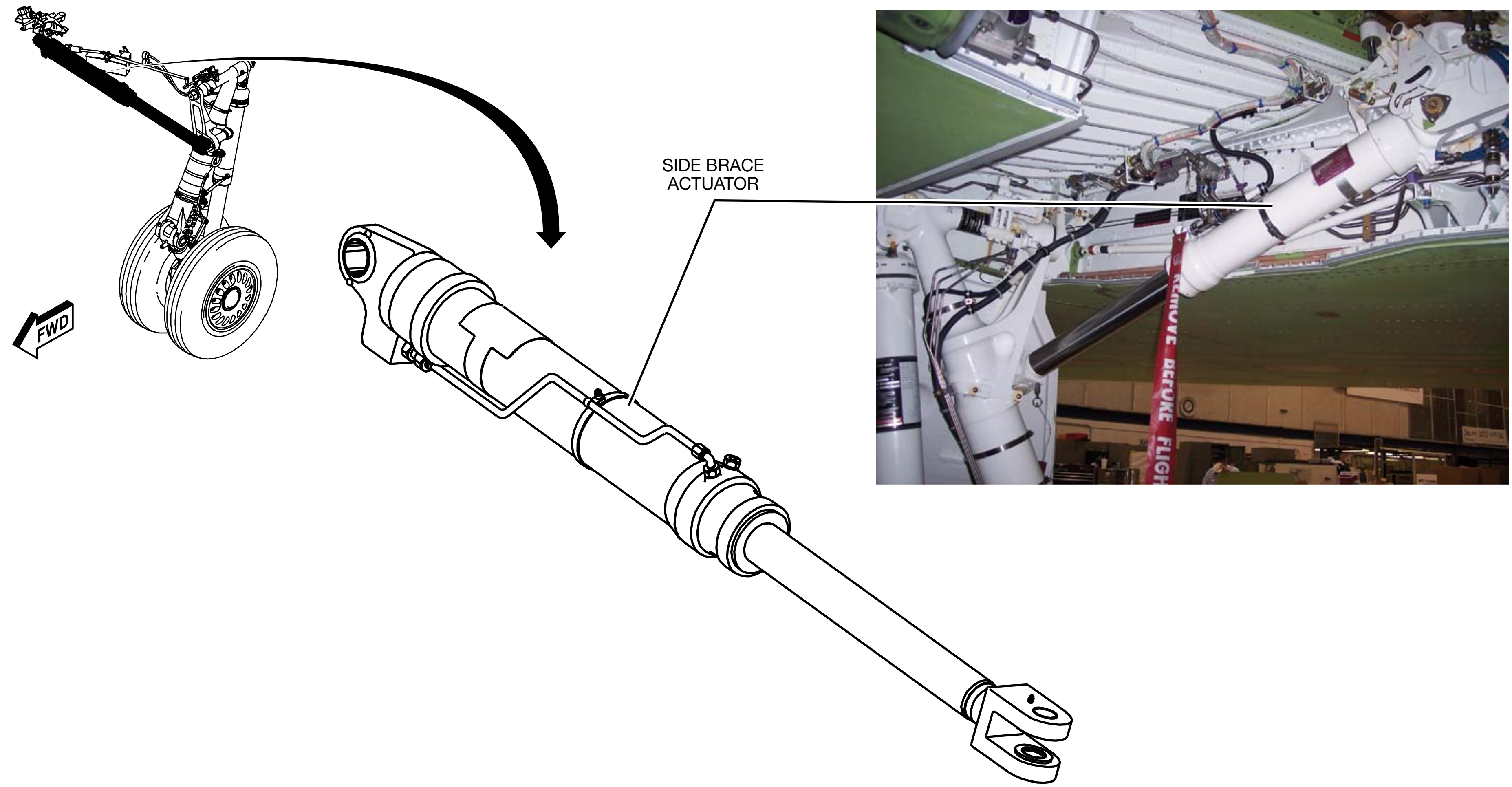

Figure 32-13. Main Landing Gear Side Brace Actuator

Side Brace Actuator

The main landing gear side brace actuator provides structural support when the gear are down, as well as hydraulic extension and retraction of the main landing gear (Figure 32-123).

The main landing gear downlock mechanism is an internal component. The side brace also contains provisions for the main landing gear downlock pin and downlock microswitch.

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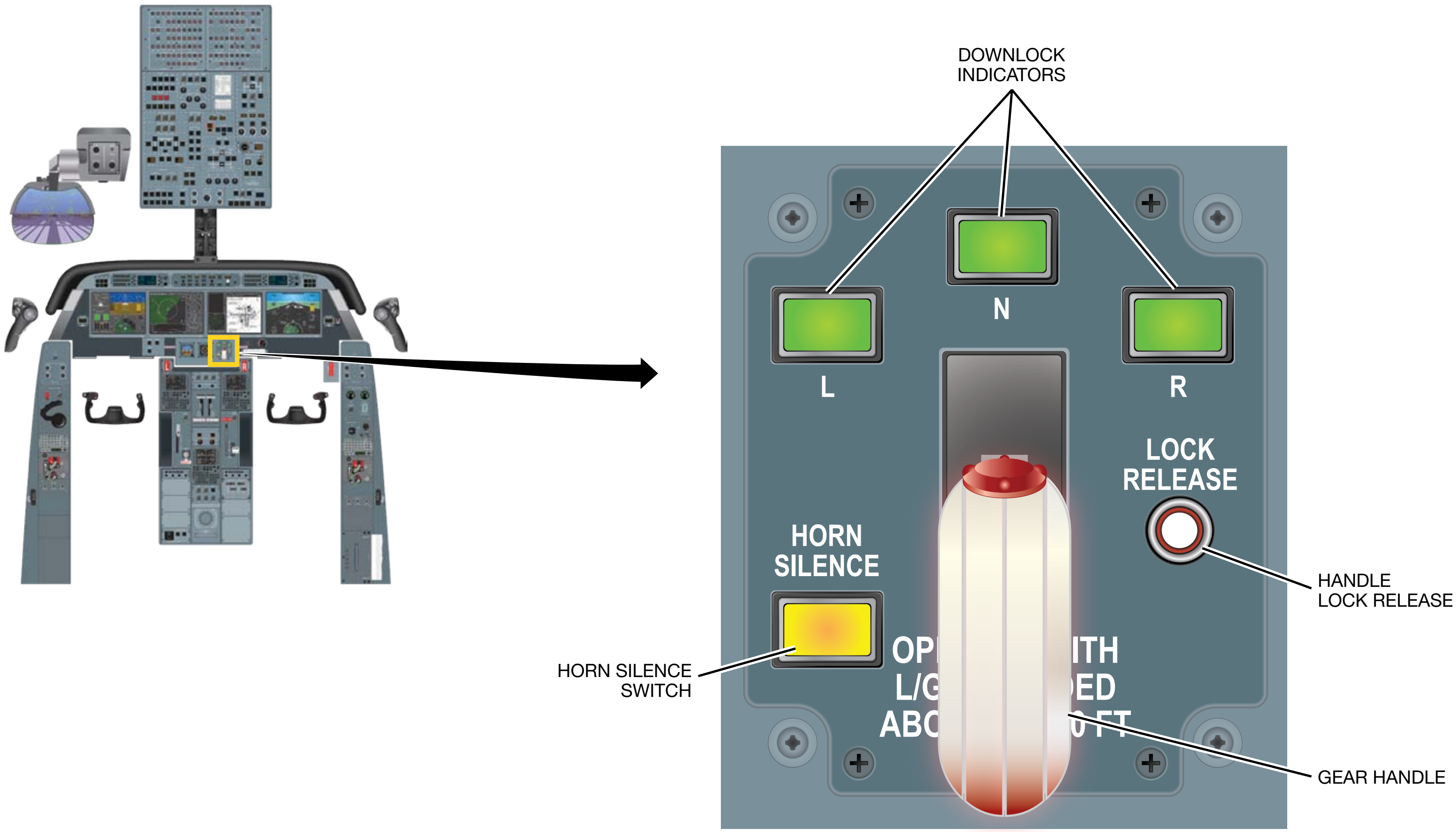

Figure 32-14. Landing Gear Control Panel

EXTENSION AND RETRACTION SYSTEM

NOSE GEAR EXTEND AND RETRACT COMPONENTS

Control Panel

The landing gear control panel is located on the lower right side of the center instrument panel and provides normal extension, retraction and indication for the landing gear (Figure 32-14).

The panel contains:

- Three down-and-locked position indicators (green)
- Horn silence switch (amber)
- Handle lock release
- Gear handle (red or white depending on certification)

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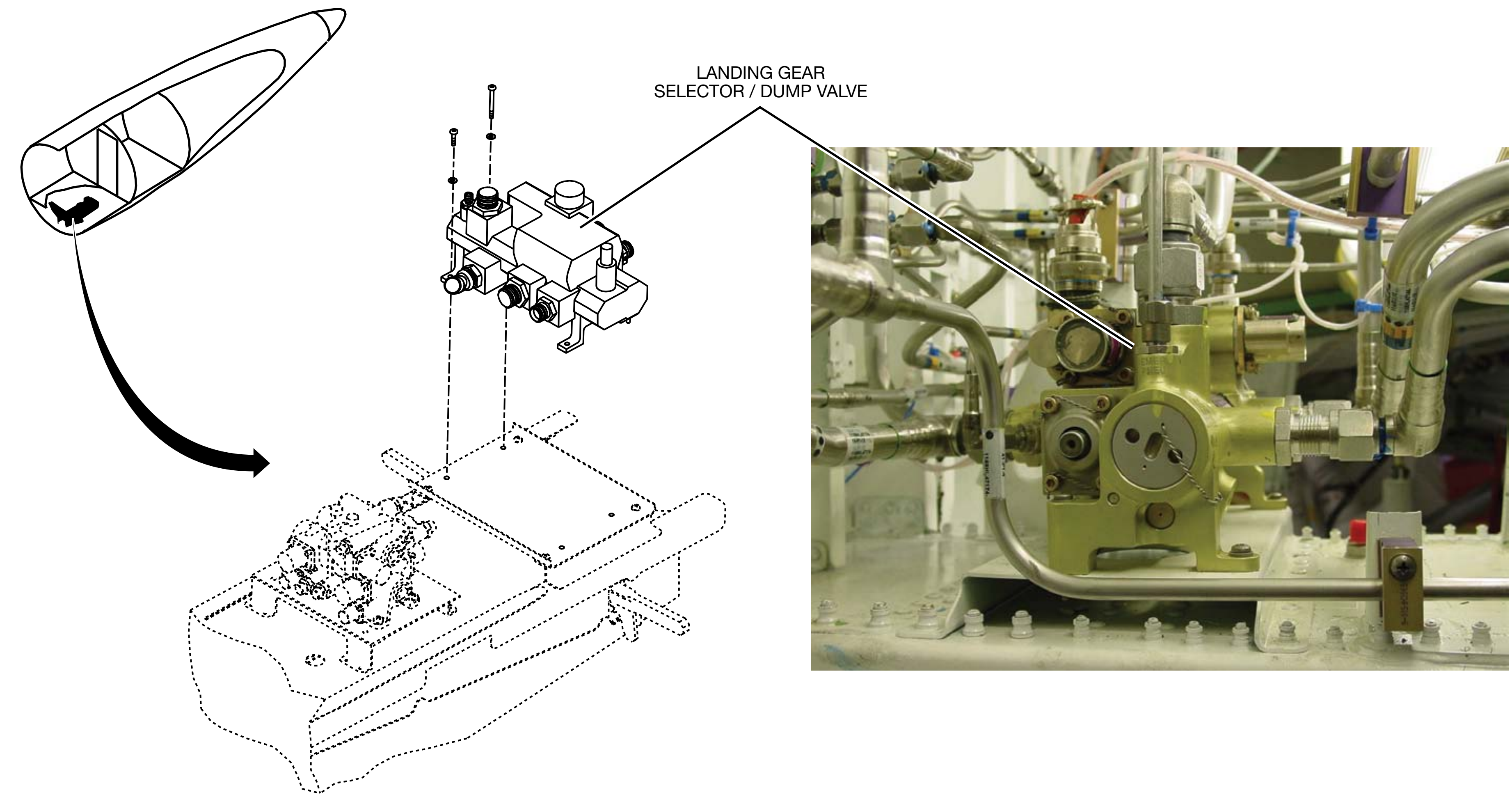

Figure 32-15. Landing Gear Selector / Dump Valve

Landing Gear Selector and Dump Valve

The landing gear selector and dump valve is located between the main landing gear on top of the torque box (Figure 32-15). It is electrically connected to the control handle in the cockpit. In addition to the selector/dump valve controlling the normal extension and retraction of the landing gear, the dump valve portion of the valve isolates the hydraulic system from the landing gear during emergency extend operation. It also provides a return fluid flow path from the landing gear components.

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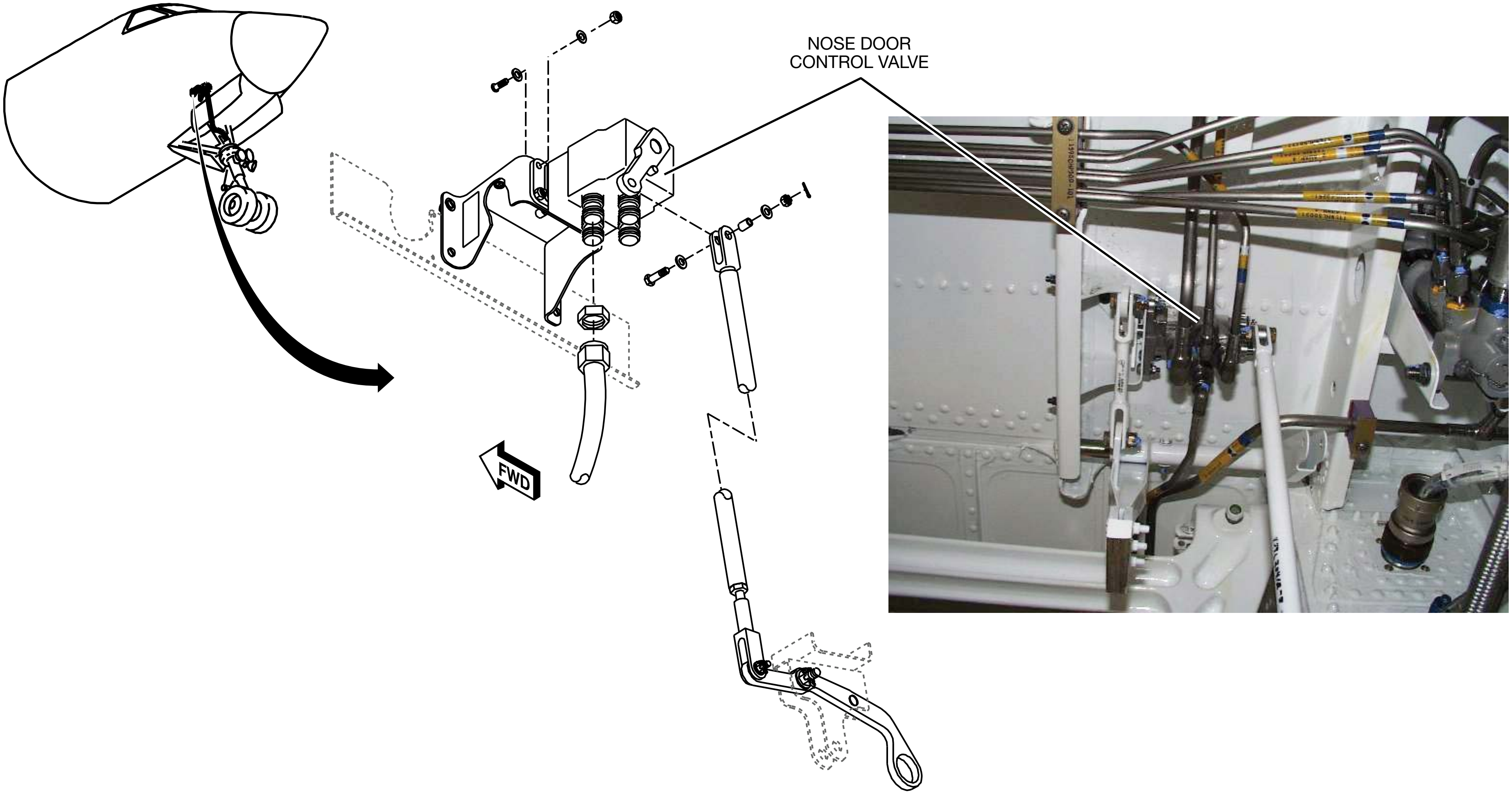

Figure 32-16. Nose Door Control Valve and Linkage

Nose Gear Door Control Valve

The door control valve controls fluid flow to and from the door actuator (Figure 32-16). It is mechanically positioned by the door control valve sequencing linkage and hydraulically locks the door actuator while the gear is in transit. The valve is positioned by the trunnion striker paddle when the gear is in the down position and by the uplock linkage in the up position.

Door Control Valve Sequence Linkage

The sequencing linkage utilized for the nose gear is a lightly loaded mechanical linkage, designed to position the door control valve in the OPEN, NEUTRAL, or CLOSED position when required. A compression spring bungee extends when the gear is being retracted and compresses when the gear is down.

The primary function of the linkage is to position the door control valve to the NEUTRAL position while the gear is in transit, preventing any damage due to the doors attempting to close while the gear is out of the UP or DOWN position.

The final function of the sequencing linkage is to ensure that as the gear enters either the fully up or fully down position, no hydraulic signal is transmitted to the door control valve closed position until the gear is in the safe position. This function is fulfilled for the extension cycle by mechanical linkage actuated by the opening of the uplock. During the retraction cycle, it is accomplished by action of the gear trunnion striker paddle disengaging the linkage when the gear begins to retract. This ensures that door motion is not initiated until the gear is sufficiently cleared for door closure. The door actuator also incorporates a shuttle valve for emergency extension operation.

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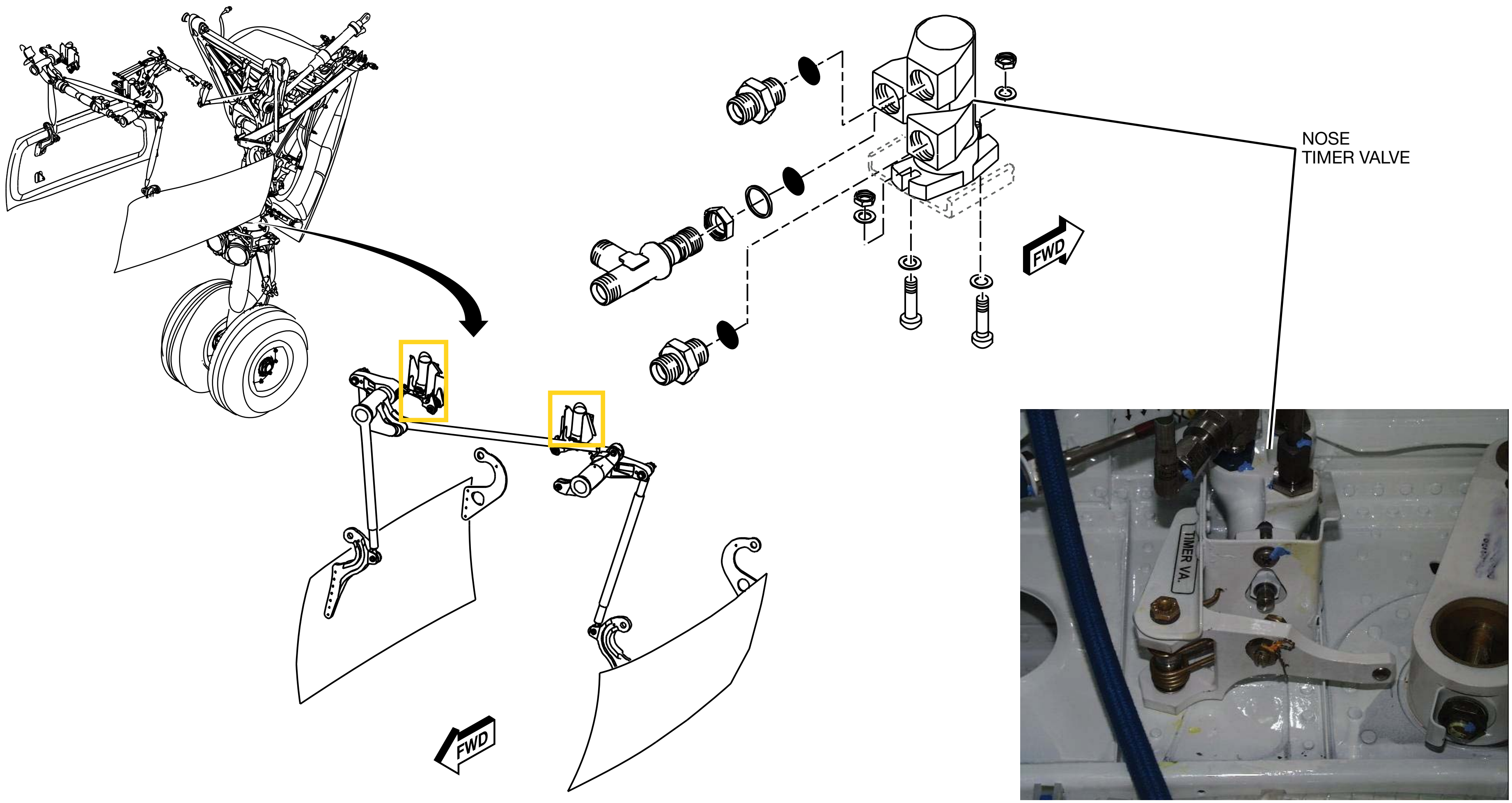

Figure 32-17. Nose Timer Valve

Extend and Retract Timer Valves

Extend and retract timer valves control the landing gear retraction and extension sequence (Figure 32-17). They are mechanically positioned open when the doors open and closed when the doors are not open. The retract timer valve prevents gear retraction until the doors are open, and the extend timer valve prevents gear unlock until the doors are open.

Nose Landing Gear Doors

The nose gear is enclosed by two hydraulically operated clamshell doors, along with a fairing door mechanically linked to the strut. Each nose gear door is supported on two separate hinges and are operated by a hydraulic actuator that powers a crank and rod mechanism at the forward end of the doors. The fairing door is supported on two separate hinges at the fuselage structure and is actuated by two fixed-length rods attached to the strut.

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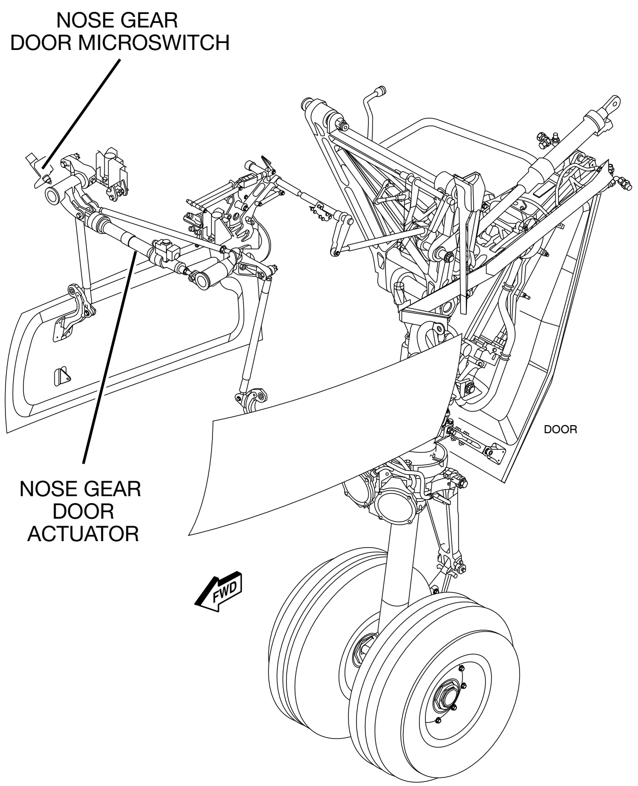

Figure 32-18. Nose Gear Door Actuator

Nose Gear Door Actuator

Location

The Nose landing gear door actuator is located aft of the forward NLG wheel well bulkhead (Figure 32-18).

Purpose

The door actuator through belcranks and push pull tubes, reconfigures the door position based on the door control valves inputs. The actuator retracts to open and extends to close the Nose Landing Gear doors.

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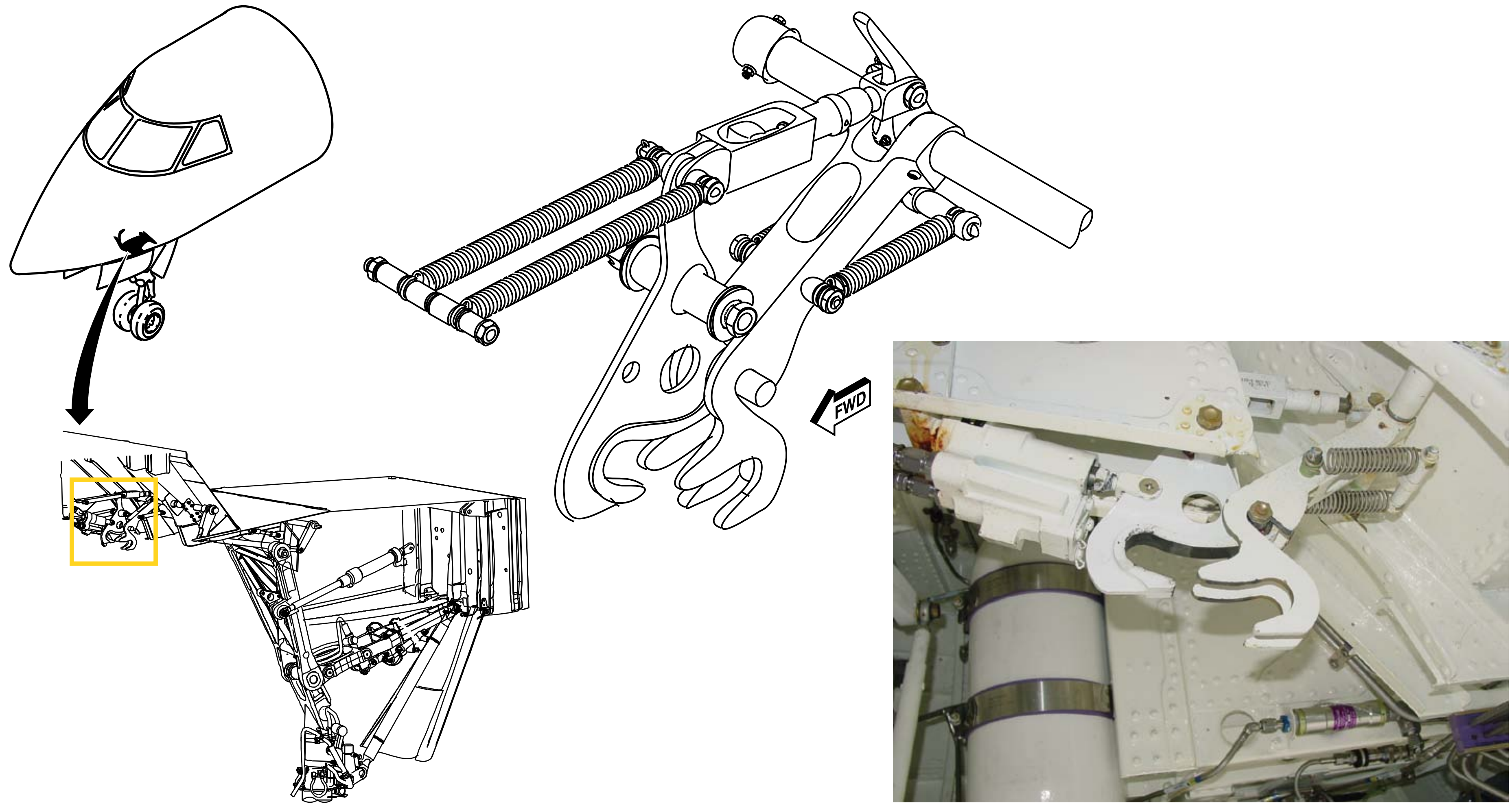

Figure 32-19. Nose Gear Uplock

Nose Landing Gear Uplock

The nose gear uplock consists of a hook and latch mechanism. The hook is mounted in the forward ceiling of the nose wheel well and is maintained in the open position by a spring-loaded latch mechanism (Figure 32-19). The hook is actuated to the lock position by a roller located near the axle of the nose strut. When the gear is fully retracted, it engages the hook and overrides the spring-loaded latch mechanism. With the latch mechanism overcome, the hydraulic actuator is allowed to retract, hydraulically locking the gear in the UP position.

The latch mechanism also provides a lock / unlock input to the door control valve sequence linkage. The uplock actuator incorporates an emergency extension shuttle valve. The uplock mechanism is designed so that any tendency of the roller to rebound out of the uplock hook resets the latch mechanism and allows normal extension of the gear.

Nose Landing Gear Actuator

The nose landing gear actuating cylinder is attached to the aircraft structure and the nose landing gear trunnion. It retracts to raise the gear and extends to lower the gear. The actuator also incorporates an emergency extension shuttle valve.

If a closed uplock is found during preflight, it must be opened prior to takeoff. Consult the *Aircraft Maintenance Manual (AMM)* for proper procedures.

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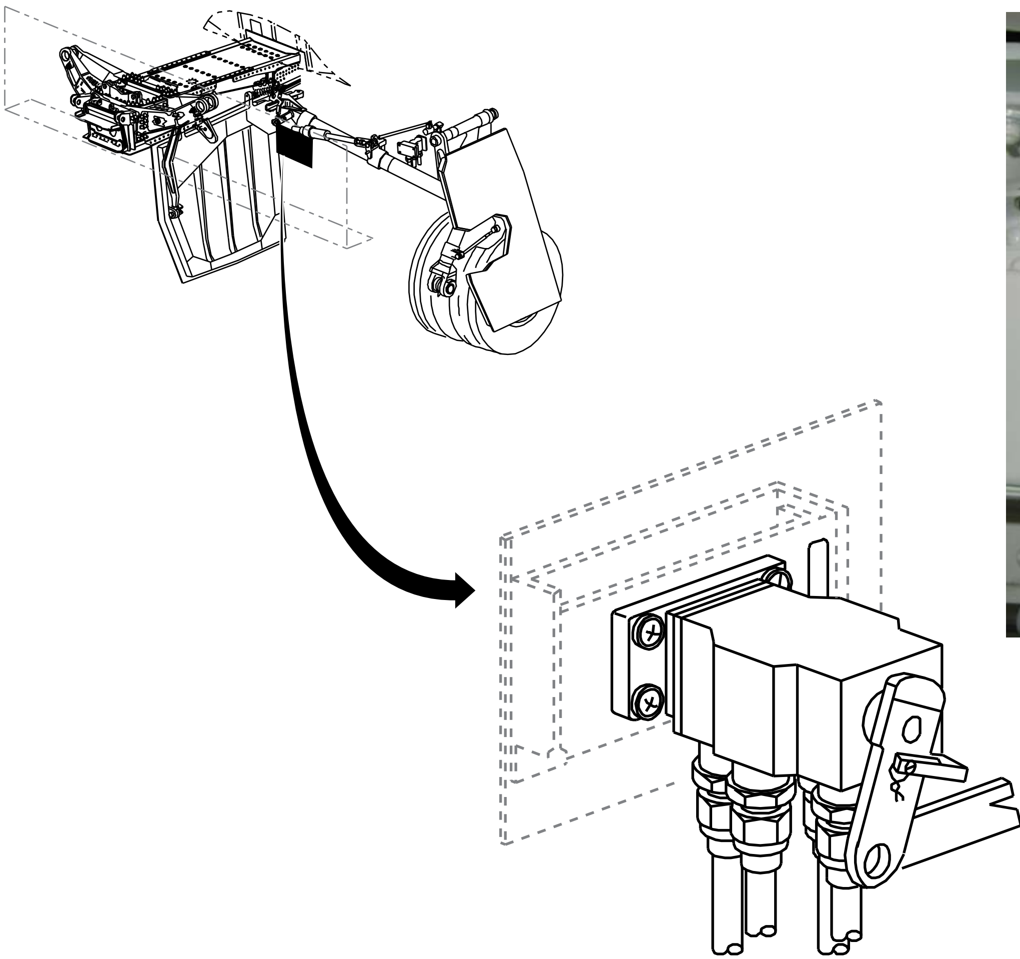

Figure 32-20. Main Landing Gear Door Control Valve

MAIN GEAR EXTEND AND RETRACT COMPONENTS

Main Gear Door Control Valve

The main landing gear door control valve controls fluid flow to and from the door actuator (Figure 32-20). The door control valve is mechanically positioned by the door control valve sequencing linkage and hydraulically locks the door actuator open when the gear is in transit. With the gear in the down position, it is mechanically positioned by the forward trunnion mount cam and in the UP position by the uplock linkage.

Door Control Valve Sequencing Linkage

The sequencing linkage utilized for the main gear is a lightly loaded mechanical linkage located on the forward side of the wheel well and designed to mechanically operate the door control valve. The primary function of the linkage is to maintain the door control valve in the neutral position any time the gear is in transit. It ensures that as the gear enters the retracted or extended position, no signal is transmitted to the door control valve until the gear is in a safe position.

During retraction, a compression spring bungee is compressed. The bungee extends when the gear is down. The sequencing linkage control is accomplished by a gear striker mounted on the top portion of the structure post, which repositions the linkage as the gear comes up. When the gear is up and locked, a fixed pushrod sends an input to the door control valve. During the extension cycle the sequencing linkage is controlled via the uplock assembly. The door actuator receives pressure from the door control valve and incorporates a shuttle valve for emergency extend operation.

Door Actuator

The main landing gear door actuator and linkage extend to close and retract to open the door. The actuator receives hydraulic pressure from the door control valve. The bellcrank and connecting arms position the doors and the timer valve cam arms.

Extend and Retract Timer Valves

The retract timer valve prevents gear retraction until the doors are open, and the extend timer valve prevents gear unlock until the doors are open. The extend and retract timer valves are mechanically positioned and control the main landing gear retraction and extension sequence. The valves are open or closed when the doors are open or closed, respectively.

Main Landing Gear Doors

Each main gear is enclosed by a hydraulically-operated, recycling, inboard door and a fairing door which is linked to the gear structural post. The fairing door opens with sufficient clearance to allow removal of the outboard main wheel without disconnecting the fairing.

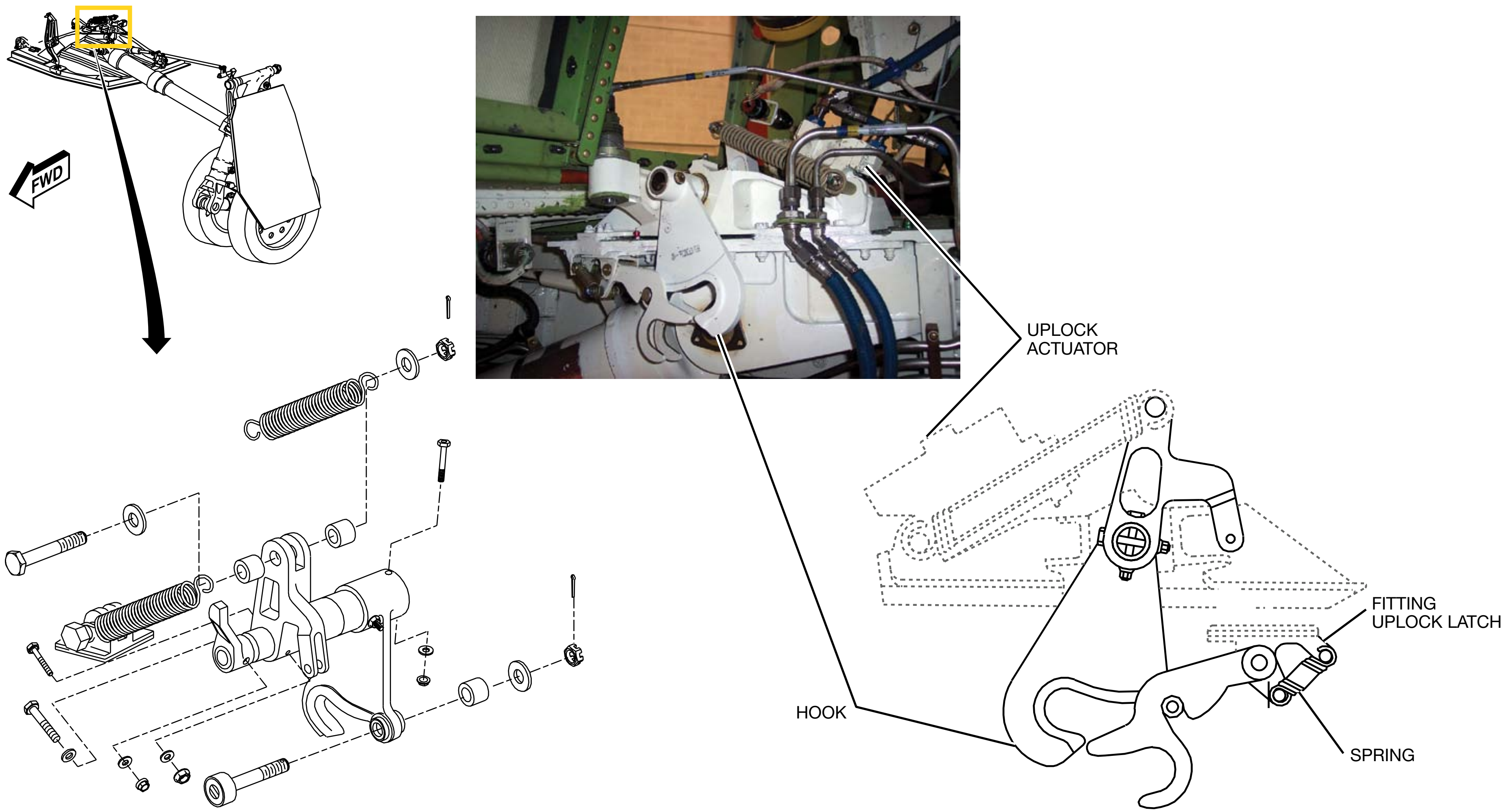

Figure 32-21. Main Gear Uplock

Main Landing Gear Uplock Mechanism

The uplock mechanism consists of a hook, latch, and uplock actuator (one in each main wheel well) (Figure 32-21). The hook, installed on the wing, engages a roller when the gear is in the up-an-locked position. It also actuates part of the sequencing linkage. The hook is actuated to the locked position by the roller engaging the hook, which overrides the spring-latch mechanism, allowing hydraulic power to keep pressure applied to the actuator in the locked position. The uplock hook is maintained in the open position by a spring-latch mechanism. The uplock actuator positions the hook to lock and unlock the gear and incorporates an emergency extension shuttle valve.

The uplock is so designed that any tendency of the uplock roller to rebound out of the uplock hook will reset the spring-latch mechanism, as will a normal extension of the gear. If an uplock is found closed during preflight, it must be opened prior to takeoff.

If a closed uplock is found during preflight, it must be opened prior to takeoff. Consult the *AMM* for proper procedures.

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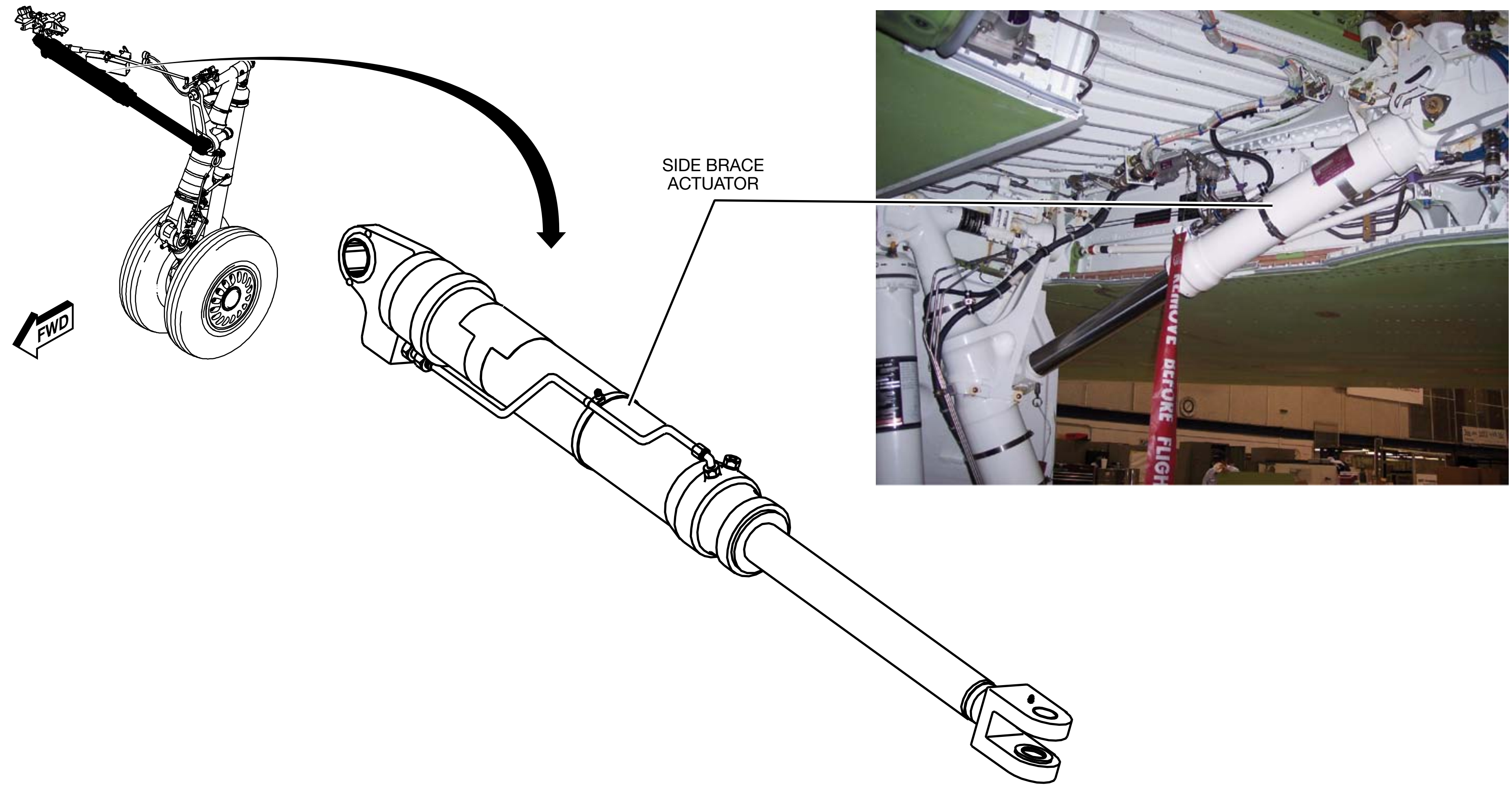

Figure 32-22. Side Brace Actuator

Main Landing Gear Side Brace Actuator

The side brace actuator is attached to the wing, and the gear structural post (Figure 32-22). It retracts to raise the gear and incorporates an external downlock switch as well as an internal downlock mechanism located in the lower end of the actuator cylinder. The principal parts that make up the downlock mechanism are three key locks and a locking ram, which is engaged with spring force.

When the side brace actuator is in the fully extended position (gear down and locked), the locking keys are engaged in an annulus integrally machined into the outer cylinder and are locked into place by the position of the locking ram (either hydraulically or by spring force with no hydraulic power applied). The action of the keys entering the locking annulus actuates a plunger mechanism attached to a microswitch, which is mounted externally on the cylinder. The downlock switch provides cockpit indication that the actuator is extended and locked. The purpose of the spring in the locking mechanism is to maintain the gear in the locked position when all hydraulic pressure is removed and with no ground safety locks installed.

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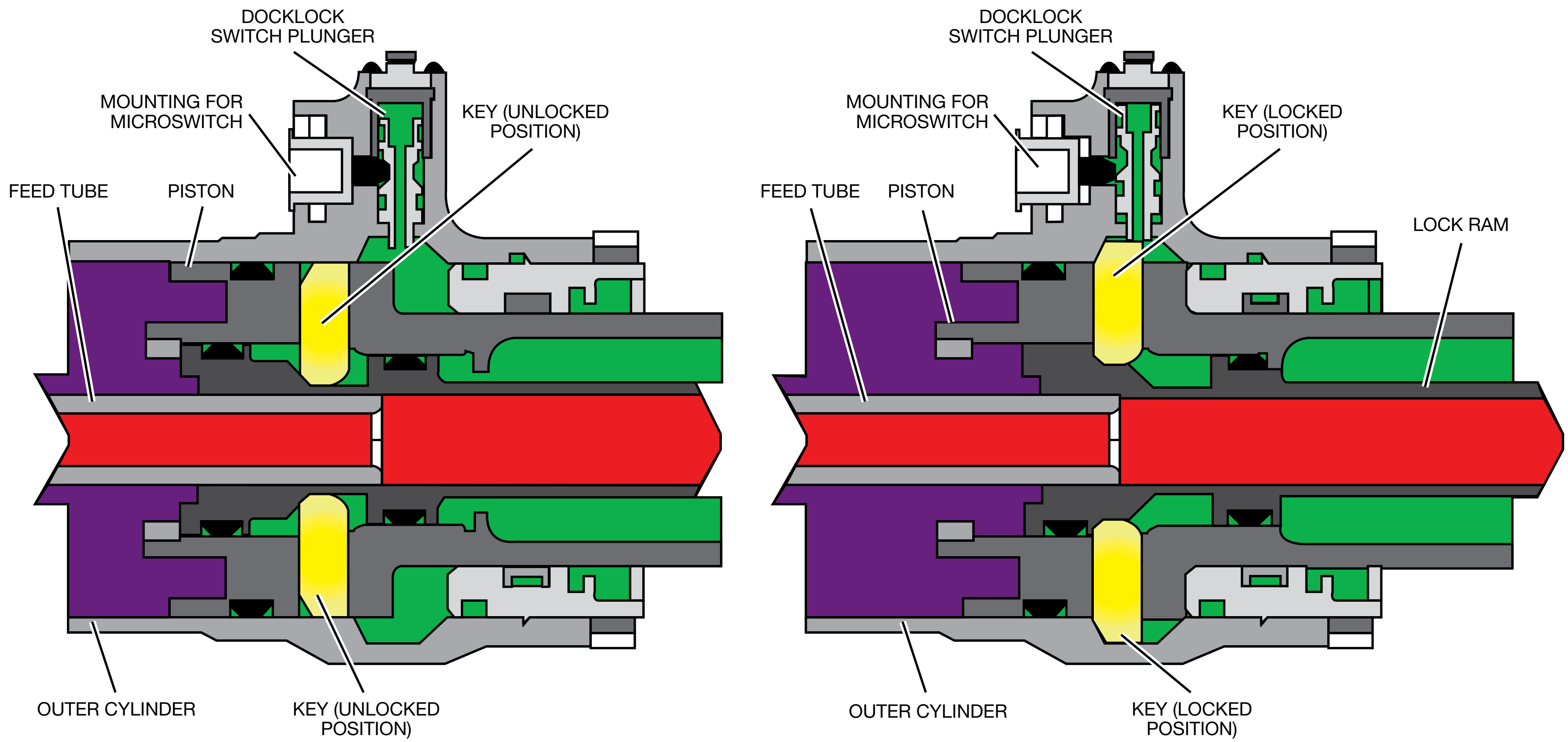

Figure 32-23. Side Brace Actuator Locking Mechanism

Main Landing Gear Side Brace Actuator (Cont)

During the unlocking sequence, hydraulic system pressure is applied to the retract side of the actuator piston. This causes the locking ram to move, overcoming the spring force freeing the locking keys in the groove. As the piston starts to retract, the locking keys are forced back into the slots provided in the piston head assembly, allowing the actuator to fully retract (Figure 32-23).

Hydraulic system pressure is always required to unlock the mechanism. The external plumbing incorporates an emergency extension shuttle valve. The power to lock the mechanism is obtained from hydraulic system pressure, pneumatic pressure (emergency gear extension), or the spring built into the mechanism.

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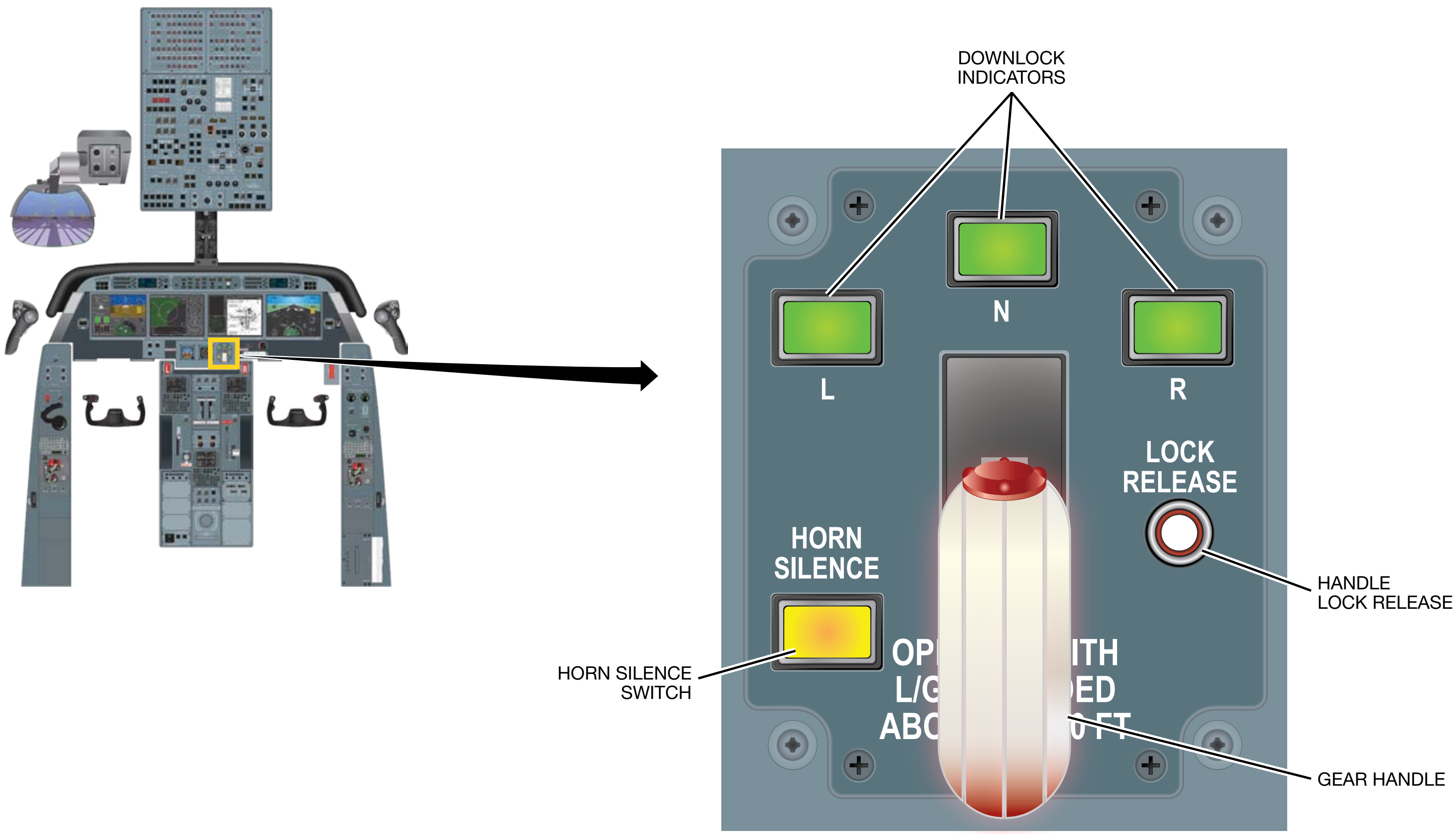

Figure 32-24. Landing Gear Control Panel

MAIN GEAR EXTEND AND RETRACT CONTROLS

Control Panel

The landing gear control panel is located on the lower right side of the center instrument panel and provides normal extension, retraction and indication for the landing gear (Figure 32-24).

The panel contains:

- Three down-and-locked position indicators (green)
- Horn silence switch (amber)
- Handle lock release
- Gear handle (red or white depending on certification)

Downlock Indicators

The three downlock indicators represent the three landing gear. The respective landing gear is locked down when the switch is illuminated green. The respective landing gear is not locked down when the switch is not illuminated green.

Horn Silence Switch

The horn silence switch is utilized to silence the audible landing gear warning horn. Pressing the switch will mute the warning tone, under certain circumstances, and the switch will then illuminate amber in color.

Handle Lock Release

The handle lock release is normally electrically operated, but can be manually operated by pressing and holding the handle lock button. Manual operation of the handle lock allows retraction of the gear if the retraction system or Weight-On-Wheels (WOW) system malfunctions. Normal ground-to-air transition energizes the solenoid to the handle lock release, pulling the button in, allowing movement of the gear handle. If the button is extended, the gear handle will be mechanically locked.

Gear Handle

The gear handle represents the position of the landing gear and is illuminated red when the gear position selected does not represent the position of the gear.

Landing gear handle lights are white on EASA / JAA aircraft.

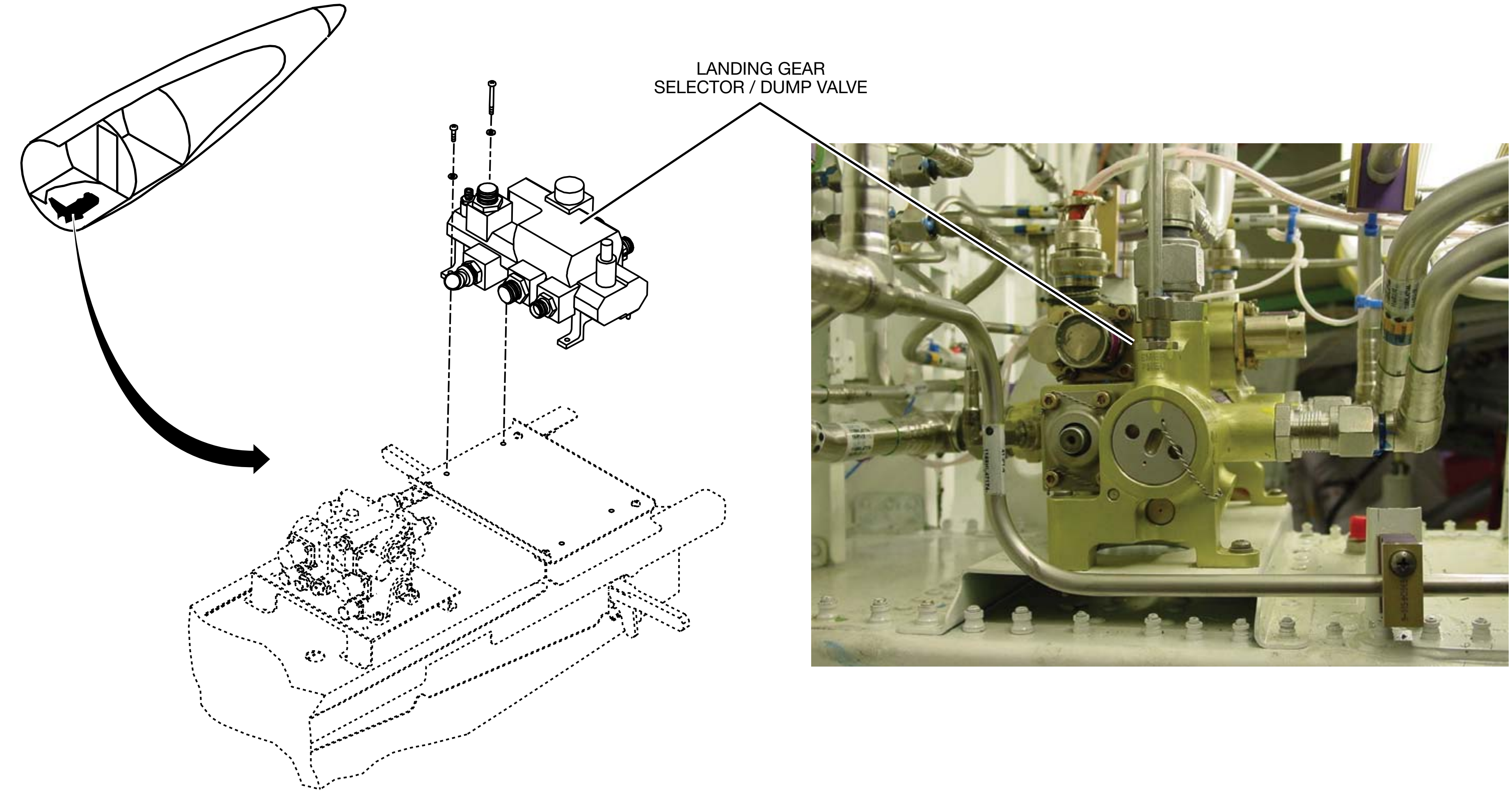

Figure 32-25. Landing Gear Selector / Dump Valve

Landing Gear Selector and Dump Valve

The landing gear selector and dump valve is located between the main landing gear on top of the torque box (Figure 32-25). It is electrically connected to the control handle in the cockpit. In addition to the selector/dump valve controlling the normal extension and retraction of the landing gear, the dump valve portion of the valve isolates the hydraulic system from the landing gear during emergency extend operation. It also provides a return fluid flow path from the landing gear components.

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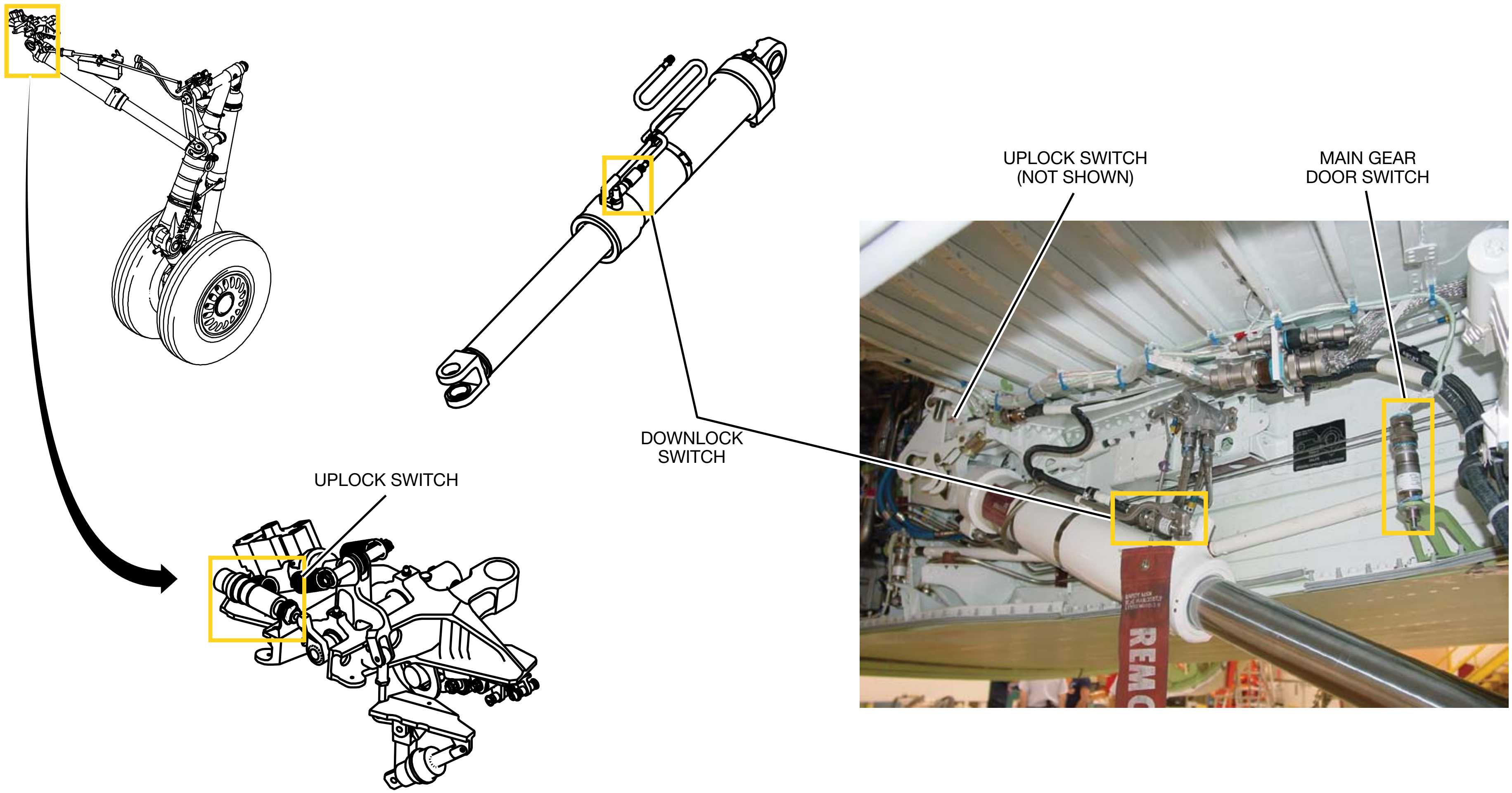

Figure 32-26. Main Landing Gear Limit Switches

MAIN GEAR EXTEND AND RETRACT INDICATIONS

General

Reference MSM 32-9. The position and warning system provides a positive indication of the position of the landing gear and gear doors (Figure 32-26). It also provides an audible warning when the gear and flaps are not properly configured for landing. The downlock switches provide down and locked indications. A red or white light in the landing gear control handle indicates that the handle disagrees with the position of the gear. If the handle has been selected down, but the gear is not down and locked yet. The gear handle light remains on until all three gears are down and locked.

The monitor warning systems 1 (TNIC / PROC1) and 2 (TNIC / PROC4) monitor power lever position when it is less than 5°, flap extension greater than 22°, and gear downlock signals. If the flap and landing gear are not configured for landing, MW1 or MW2 will provide an audio warning to the crew through the cockpit audio system.

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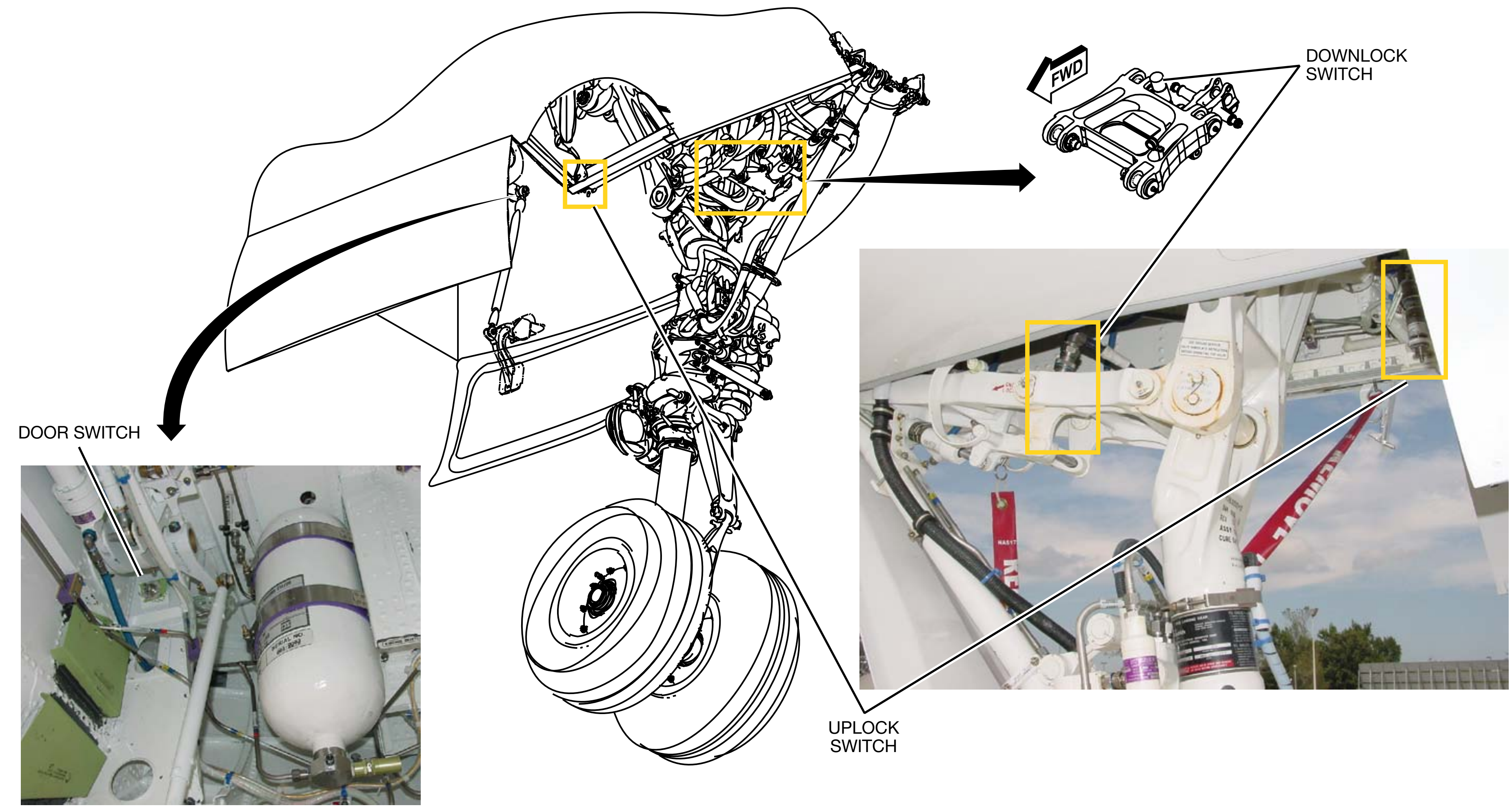

Figure 32-27. Nose Landing Gear Limit Switches

General (Cont)

Landing gear position information is provided by annunciators located on the landing gear control panel and by CAS warning messages. Signals are provided by three four-pole limit switches located on each gear mechanism. The three switches are for gear down locked, gear up locked, and main landing gear door position (Figure 32-27). Electrical power is supplied by the 28VDC right emergency DC bus through the LANDING GEAR INDICATION circuit breaker. Note the nose landing gear up-lock indication is activated by the follow-up door attached to the NLG post.

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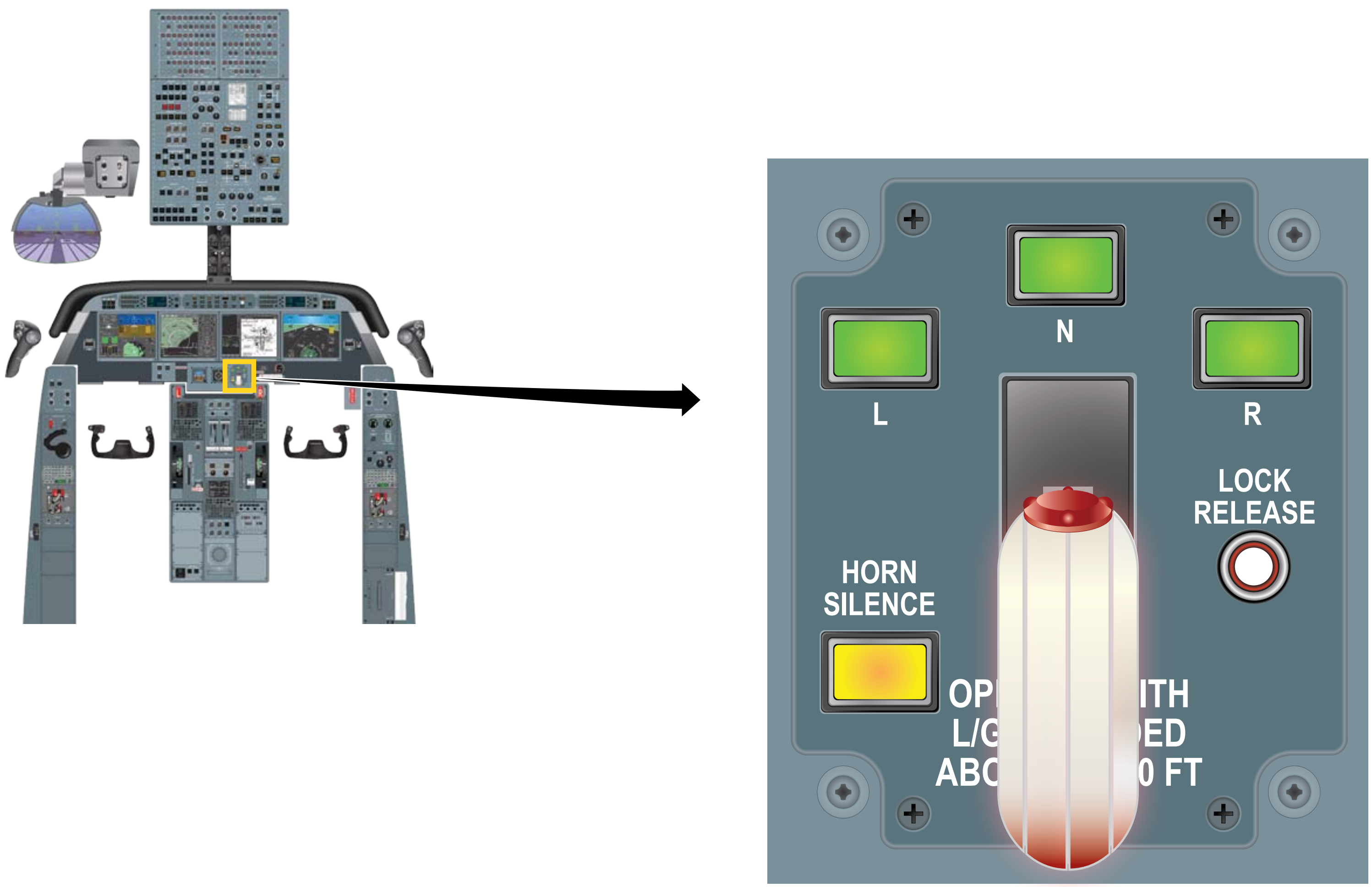

Figure 32-28. Landing Gear Control Panel

Landing Gear Control Panel

The control panel contains the three green DOWN annunciators that illuminate when the respective landing gear is in the down-and-locked position (Figure 32-28).

A red or white annunciator light in the landing gear control handle illuminates whenever there is disagreement between the handle position and the position of the landing gear. On gear retraction, the light remains illuminated until each gear is fully up and locked and its gear door is closed. On gear extension, the light remains illuminated until all three gears are down and locked.

The landing gear panel contains a HORN SILENCE button so that the warning horn can be manually silenced, if desired. Also, a lever lock release solenoid on the right side of the control panel locks the gear handle until until energized by the weight off wheels system.

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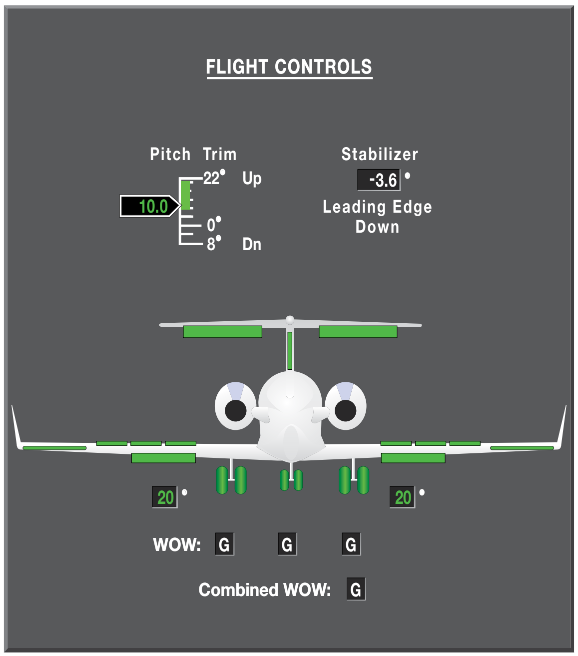
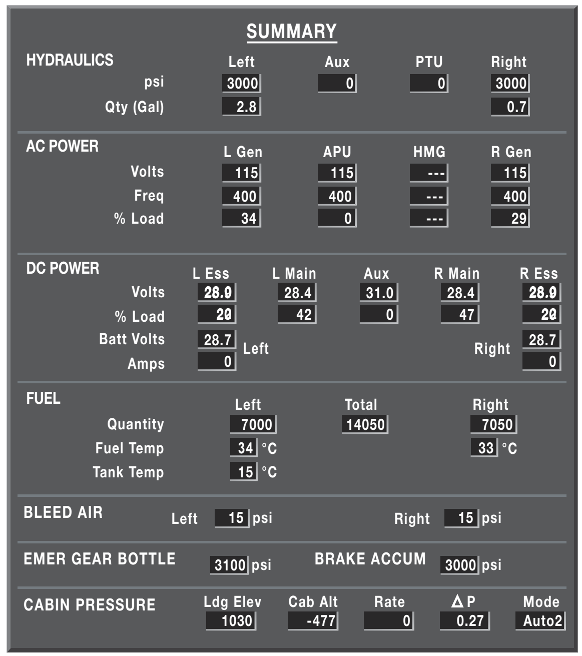
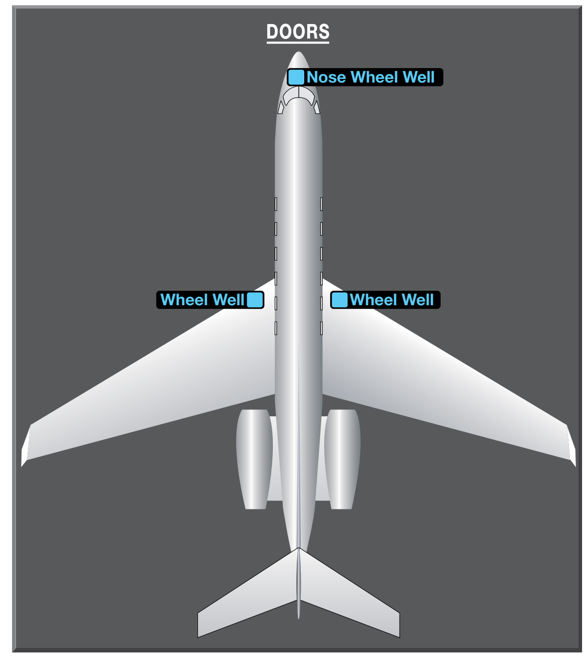


FLIGHT CONTROLS SYNOPTIC



SUMMARY SYNOPTIC



DOORS SYNOPTIC

Figure 32-29. Synoptic Pages

Synoptic Pages

Synoptic Display

Landing gear information is presented on the flight controls synoptic page. The flight controls synoptic page shows a representation of the three landing gears with three tire symbols (Figure 32-28). The three tires are displayed normally in green whenever the landing gear is down and locked and disappear when the landing gear is retracted with doors closed. The synoptic page tire symbols will turn magenta when the gear is in transit to be consistent with the landing gear handle light. When the landing gear is in transit, the landing gear handle light on the control panel is illuminated red. The strut graphics, including tire symbols, are removed if the:

- Gear handle is UP
- Gear is UP
- Gear door is not open

NOTE

Landing gear handle lights are white on EASA / JAA Aircraft.

Additional information on the door position can be found on the doors synoptic page (Figure 32-29). Any time the landing gear is prevented from uplocking, the landing gear door is mechanically prevented from closing. Therefore, if the gear is causing illumination of the red handle light, only the “GEAR NOT UP” warning is provided and not the “GEAR DOOR OPEN” message, since it is assumed that the door cannot close.

Fault Indications

The CAS caution messages are provided for:

- Not downlocked
- Not uplocked
- Door not closed

After the landing gear handle has been positioned by the pilot, CAS warning messages are delayed for a period of 15 seconds to allow for landing gear movement. During landing gear retraction either a gear not up and locked or a gear door not closed can cause the red landing gear handle light to illuminate. Since the pilot cannot determine which situation has caused the red light in the gear handle to stay illuminated, CAS messages help the pilot determine the specific failure.

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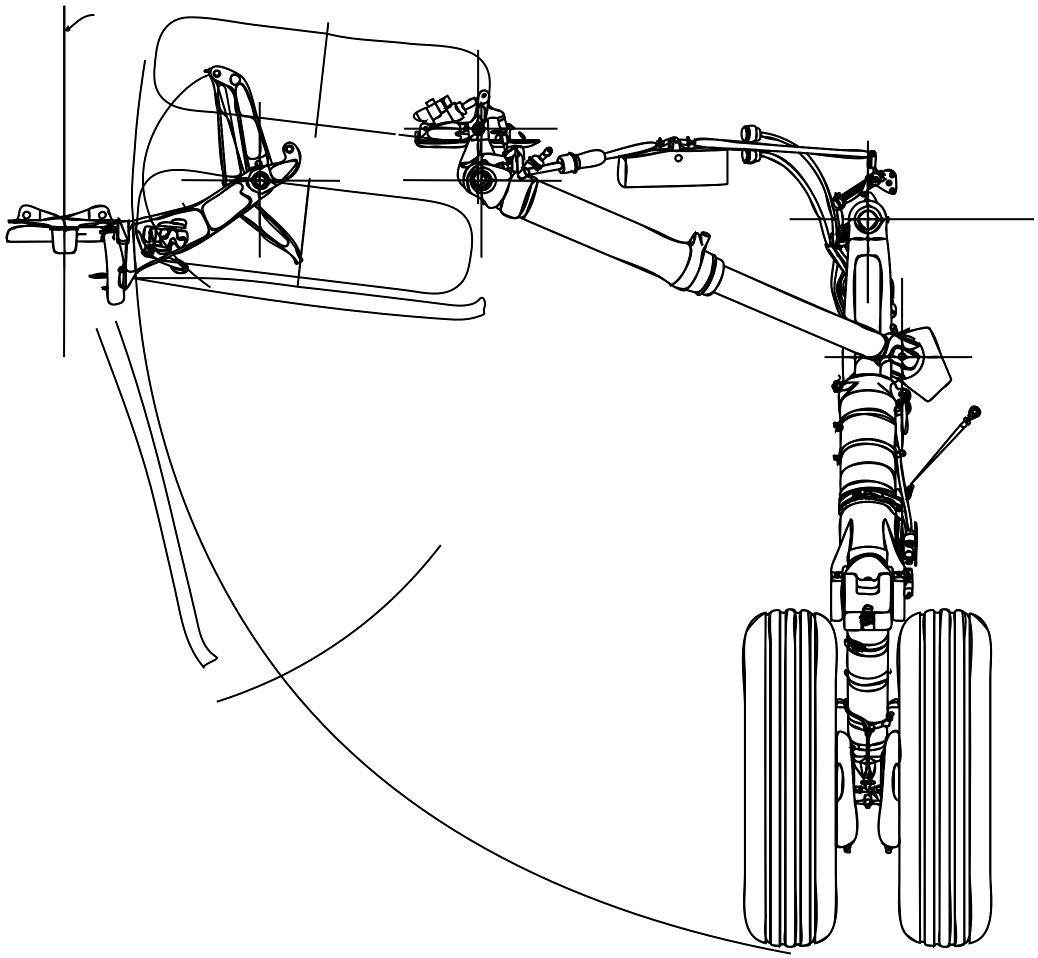

Figure 32-30. Main Gear Operation

MAIN GEAR EXTEND AND RETRACT OPERATION

The landing gear is extended (down) and retracted (up) using the left hydraulic system with the PTU as backup. The landing gear control handle is located near the center of the forward instrument panel and is electrically connected to the landing gear selector / dump valve assembly, which contains two solenoid-controlled valves.

The landing gear movement is controlled electrically by a switch activated by the landing gear control handle. The switch sends electrical power to the solenoid-actuated hydraulic selector valve, which ports hydraulic fluid to the actuators. Electrical power is supplied from the 28VDC right emergency bus through the LDG GEAR CONT circuit breaker, located on the pilot's overhead control circuit breaker panel, and the landing gear indication circuit breaker, located on the REER panel. Electrical power is removed from the solenoid when gear movement has been completed.

Initially, with the landing gear down, both main and nose gear doors are closed. When the landing gear up position is selected, the landing gear doors open, the nose gear strut retracts forward to the up-and-locked position, and the main gear retract inboard to the up-and-locked position. The main and nose gear doors close, completing the up cycle. When the landing gear down position is selected, the main and nose gear doors open, allowing the gears to extend to the down-and-locked position and the gear doors to close, completing the down cycle (Figure 32-30).

A ground safety lock solenoid is incorporated in the landing gear handle panel. This solenoid prevents inadvertent movement of the landing gear handle to the gear-up position while the aircraft is on the ground. In the event of a solenoid malfunction, a manual override is provided on the landing gear handle panel to release the lock.

Audio Warning System

The landing gear audio warning is provided by the Monitor Warning systems (MW). The MW systems monitor power lever position, flap extension, and gear downlock signals. When specific combinations of these conditions exist, the gear audio warning is provided. The crew is alerted by a warning tone when the three following landing gear conditions exist:

- Both throttle levers are below 5°, and any gear is not down and The aircraft is at or below 345 feet radio altitude, a power lever is retarded to 5° or less and all landing gear not down and locked. The warning horn may be silenced with the switch in this condition
- If the power lever(s) is subsequently advanced to more than 5°, the aircraft climbs above 345 feet or if calibrated airspeed drops below 60 knots (a speed only associated with ground operation in the instance of WOW system failure), the HORN SILENCE switch light will go out and the horn warning circuit will rear.
- The flaps selected to more than 22° and all landing gear not down and locked regardless of altitude. The warning horn cannot be silenced and will sound until the aircraft configuration is corrected.

The audio tone can be manually muted by pressing the HORN SILENCE switchlight on the landing gear control panel. When the tone is muted, the switchlight illuminates, reminding the crew that the warning horn had been silenced.

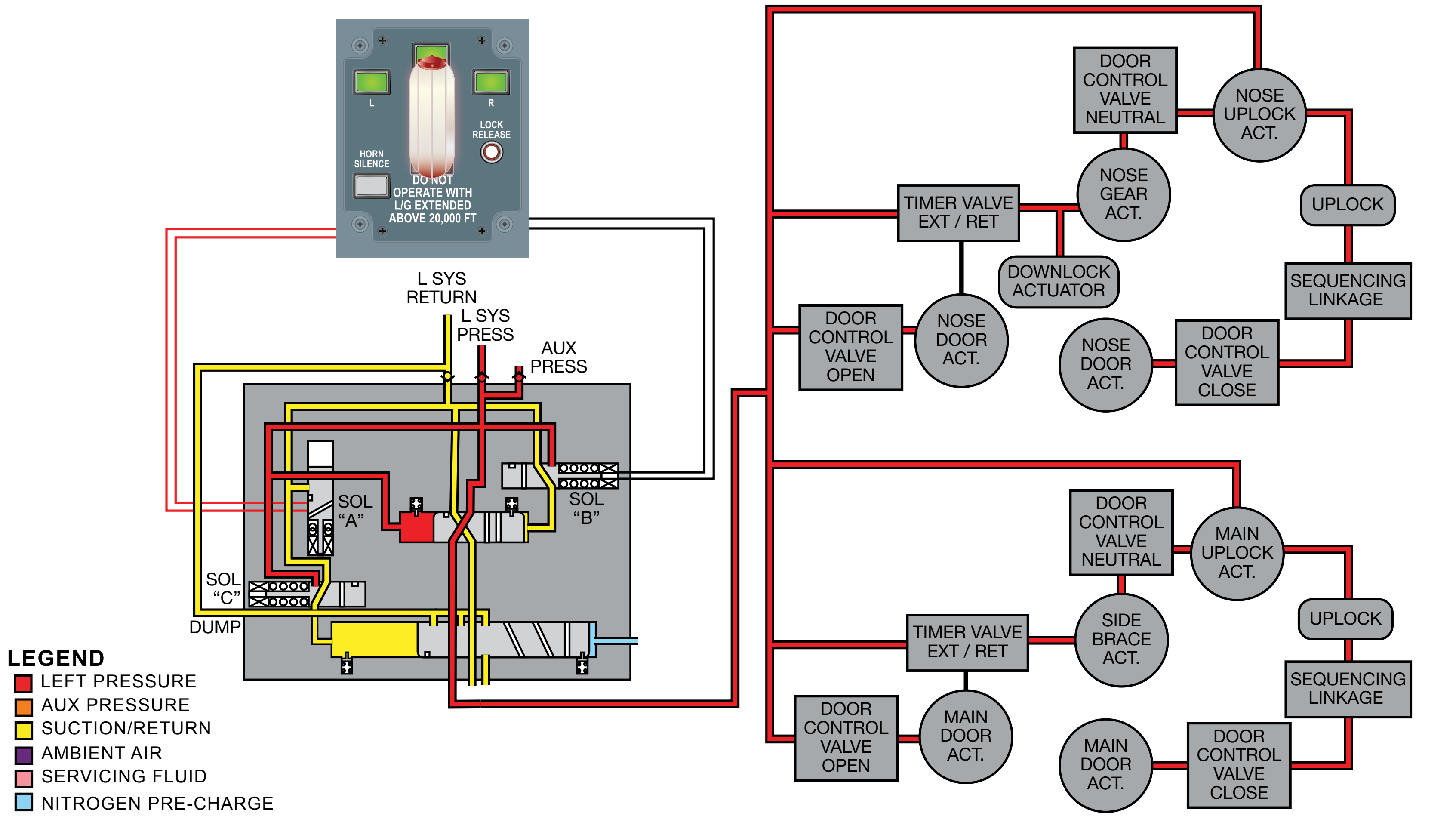

Figure 32-31. Retract Sequence

Landing Gear Retract Cycle

With the landing gear handle in the retract position, an electrical signal is sent to the landing gear selector/dump valve unit in the torque box area between the main wheel wells (Figure 32-31). The selector valve up solenoid is energized to allow hydraulic pressure to port to the following locations:

- Uplock actuator—Cannot lock at this time, as the uplock latch mechanically retains the hook in the open position.
- Retract timer valve—Remains in the closed position at this time, as the landing gear door operation is required to depress the valve plunger to open the valve.
- Door control valve—Allows pressure to flow through the valve to the open port at the rod end of the actuator, retracting the door actuator and opening the landing gear doors.

The final motion of the doors actuates the door mechanical linkage to depress the two timer valve plungers simultaneously. This action directs pressure from the retract timer, through a restrictor, to the unlock port of the nose downlock actuator, and the retract ports of the nose gear and side brace actuators. The hydraulic pressure will then unlock the downlock linkages and retract the gear. As the gear retracts, mechanical sequencing linkage causes the door control valve to be positioned to the neutral position, which in turn prevents flow to the door actuator while the gear is in motion. At this time the door actuator is hydraulically locked.

As the gear enters the fully up position, the uplock roller mounted on the strut base strikes the uplock latch assembly, which performs two functions. First, it releases the uplock hook, allowing the uplock actuator piston to extend so that the hook can engage the uplock roller, locking the gear in the up position. Next, when the uplock actuator piston extends, it actuates the mechanical sequencing linkage to reposition the door control valve. Pressure is diverted through the door control valve and a flow regulator to the head end of the door actuating cylinder, extending the piston and closing the doors.

With the retraction cycle completed, the landing gear components are positioned as follows:

- Gear actuator (nose landing gear) and the gear side brace actuator (main landing gear) are unpressurized in the retracted position.
- Timer valve pressure ports close, and the valve return port opens, allowing the pressure to dissipate.
- Recycling doors are closed and locked, and the door actuator is pressurized in the fully extended, door-closed position.

The uplock actuator piston is pressurized and maintains the uplock hook in the closed-and-locked position. The door control valve is in position, to allow hydraulic pressure to be continuously applied to the door actuator close side and is also ready to port fluid to the door actuator open side when the landing gear extend position is selected.

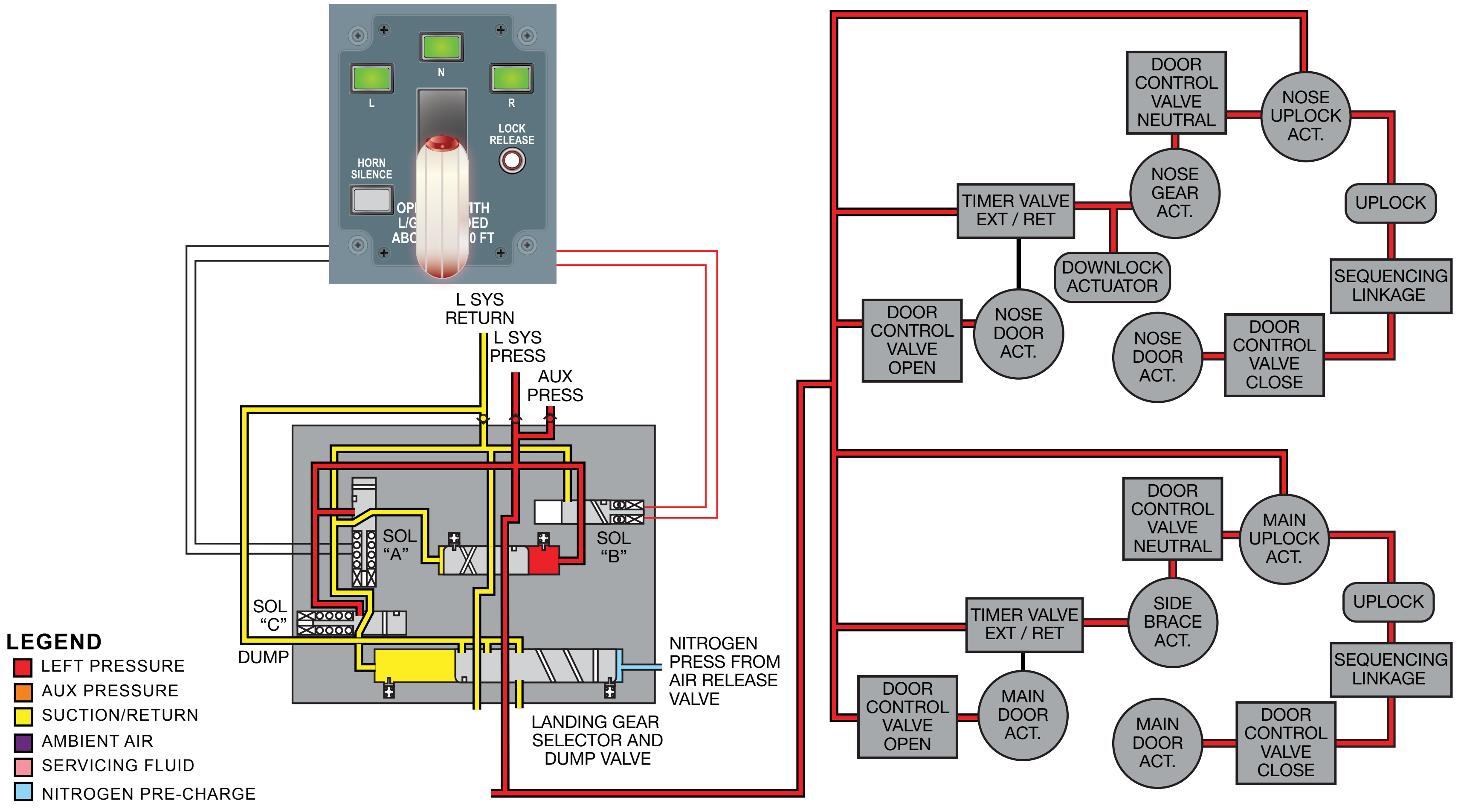

Figure 32-32. Extend Sequence

Landing Gear Extend Cycle

With the landing gear handle in the extend position, an electrical signal is sent to the landing gear selector valve down solenoid, which is energized to allow hydraulic pressure to port to the three following locations (Figure 32-32):

- Nose gear actuators/main gear side brace actuator extend port—Remains idle while the uplock hook retains the gear in the up-and-locked position.
- Uplock timer valve—Remains in the pressure-blocked position, awaiting the nose gear door operation cycle to depress the door control valve plunger.
- Door control valve—Allows the fluid to flow to the open port of the door actuator rod end, retracting the actuator piston and opening the landing gear doors.

The final opening motion of the doors actuates the cranks and linkage to depress the two timer valve plungers and directs pressure from the extend timer valve to the uplock actuator, retracting the piston and releasing the uplock hook. The first motion of the uplock assembly actuates the sequencing linkage, which returns the door control valve to the neutral position, preventing flow to the door actuators while the gears are in motion.

The nose landing gear downlock actuator is hydraulically pressurized, but is mechanically prevented from extending. With the extend port of the nose landing gear actuator and side brace actuator already pressurized, the gear extends as soon as the uplock hook reaches the unlock position. When the gear approaches the almost fully extended position, the striker paddle moves the mechanical sequencing linkage, repositioning the door control valve to port pressure. Fluid flows through the control valve and a flow regulator to the close port of the door actuator. This action extends the piston and recycles the door closed to complete the cycle. With the extension cycle completed, the landing gear components are positioned as follows:

- The gear side brace actuator is pressurized and locked in the fully extended position
- The recycling door is closed and locked, and the door actuator is pressurized in the extended (door closed) position.
- The timer valves are closed (door closed), allowing return flow of fluid to the reservoir.
- The uplock actuator is unpressurized in the fully extended (main landing gear) or retracted (nose landing gear) position and is maintained in that position by the spring-loaded uplock latch assembly.

The door control valve is positioned to permit fluid flow to the landing gear door actuator open side when the landing gear up pressure is applied on the next selection.

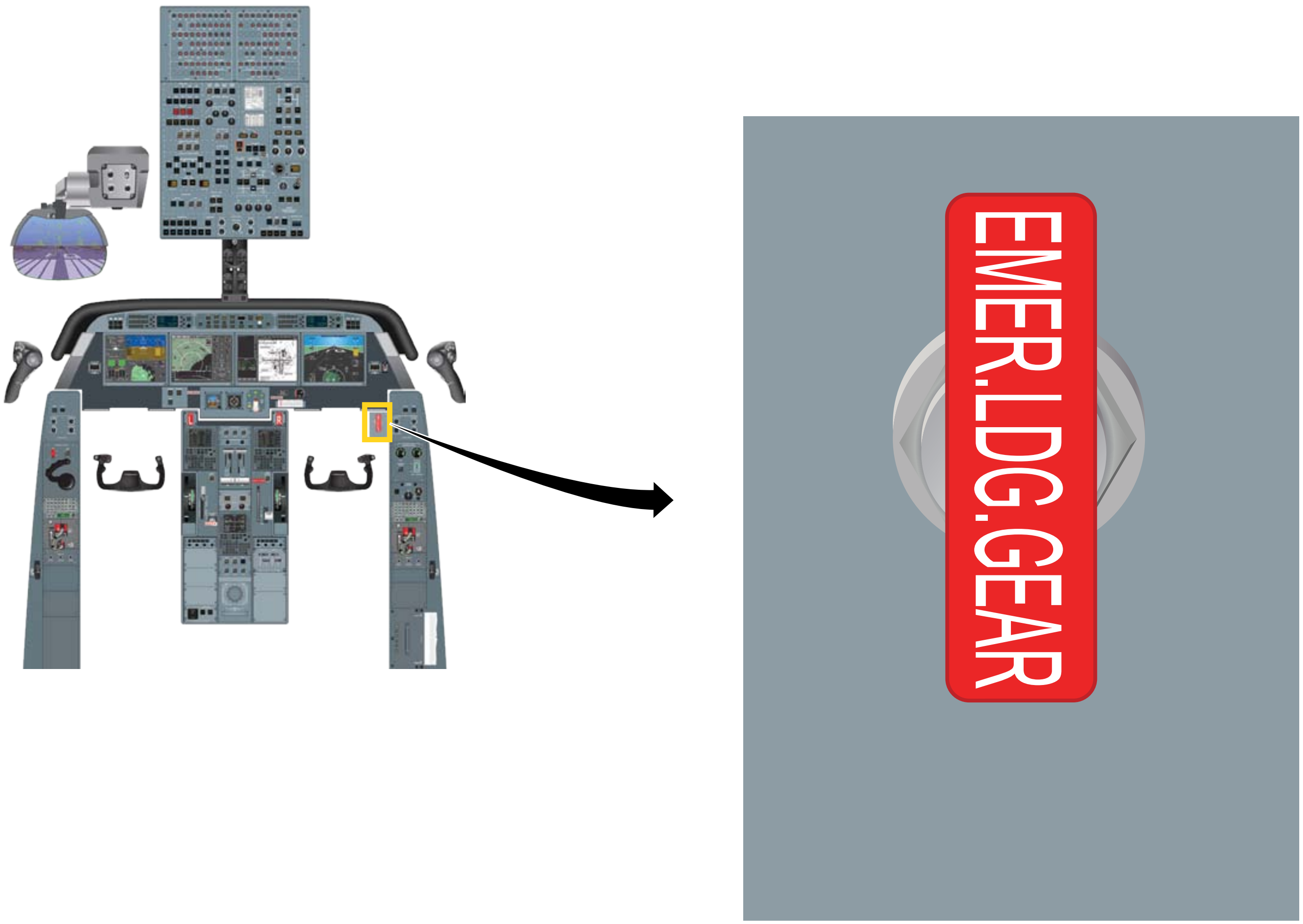

Figure 32-33. Emergency Extension Handle

Landing Gear Emergency Extension System

LANDING GEAR EMERGENCY EXTENSION DESCRIPTION

In the event that the landing gear normal operating system fails to extend the landing gear, a nitrogen blowdown system can extend and lock the gear. The system components include:

- Cockpit “T” handle
- Air-release valve
- Nitrogen storage bottle
- Nitrogen servicing panel
- Cockpit reset panel

LANDING GEAR EMERGENCY EXTENSION COMPONENTS

Emergency Extension T-Handle

The emergency extension T-handle is located on the forward side of the copilot’s side panel and initiates the landing gear emergency extension (Figure 32-33). It is a mechanical linkage that connects to the emergency extension air release valve.

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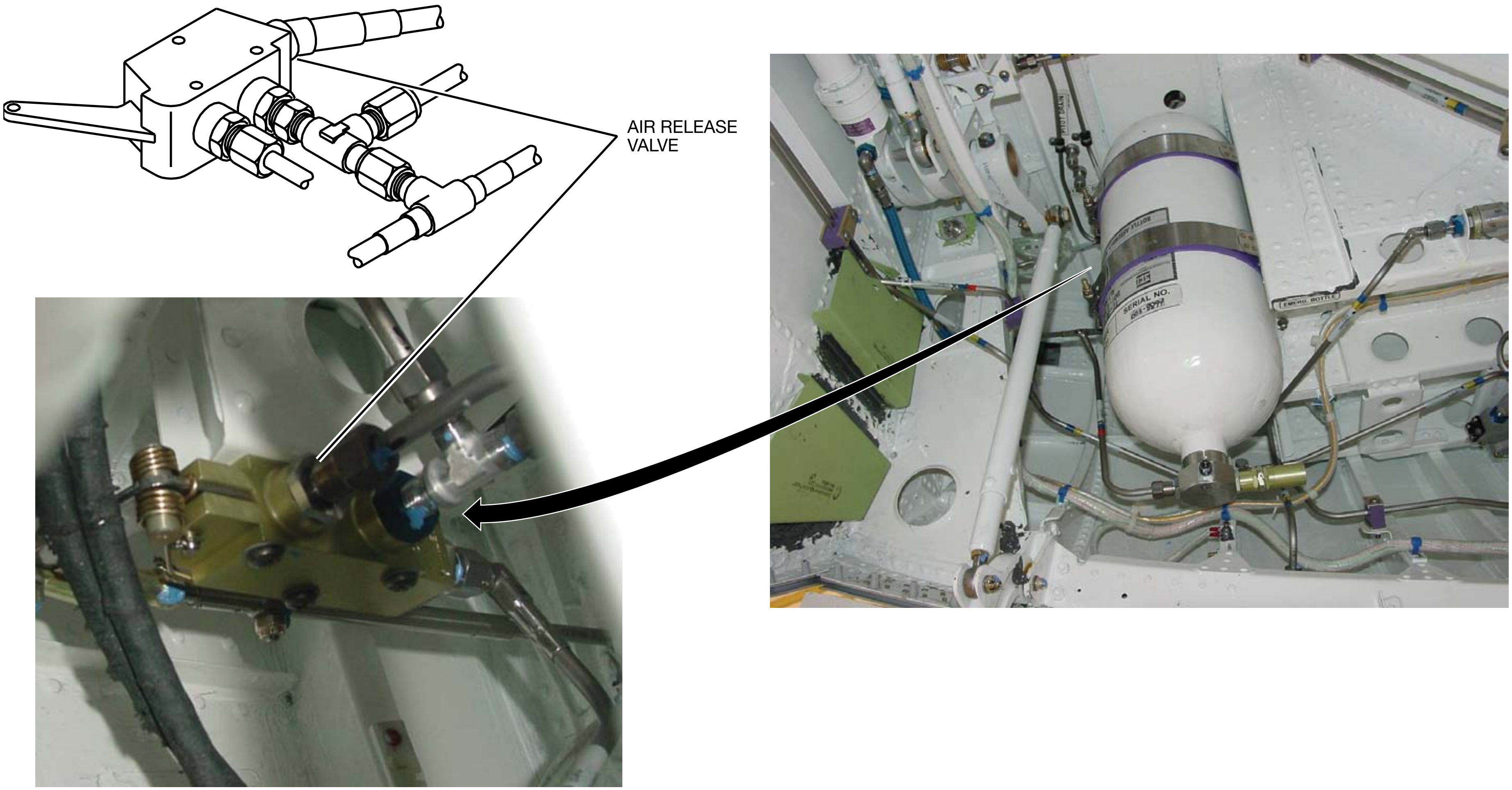

Figure 32-34. Air Release Valve

Emergency Extension Air Release Valve

The pneumatic, three-way, two-position control and vent valve is located in the upper right side of the nose wheelwell (Figure 32-34).

The valve has three ports:

- Inlet (from the landing gear emergency extension bottle)
- Outlet (to the landing gear emergency extension system)
- Vent (overboard)

When the emergency landing gear T-handle is pulled into the detent position, the air release valve lever closes the vent port and opens the outlet port, permitting 3,100 psi of nitrogen pressure to flow from the emergency landing gear bottle. The high pressure nitrogen is directed to the dump valve portion of the landing gear selector dump valve and out through separate lines abd shuttle valves to the nine actuators that drive the landing gear doors open, release the uplock and force the gear down and into the locked position.

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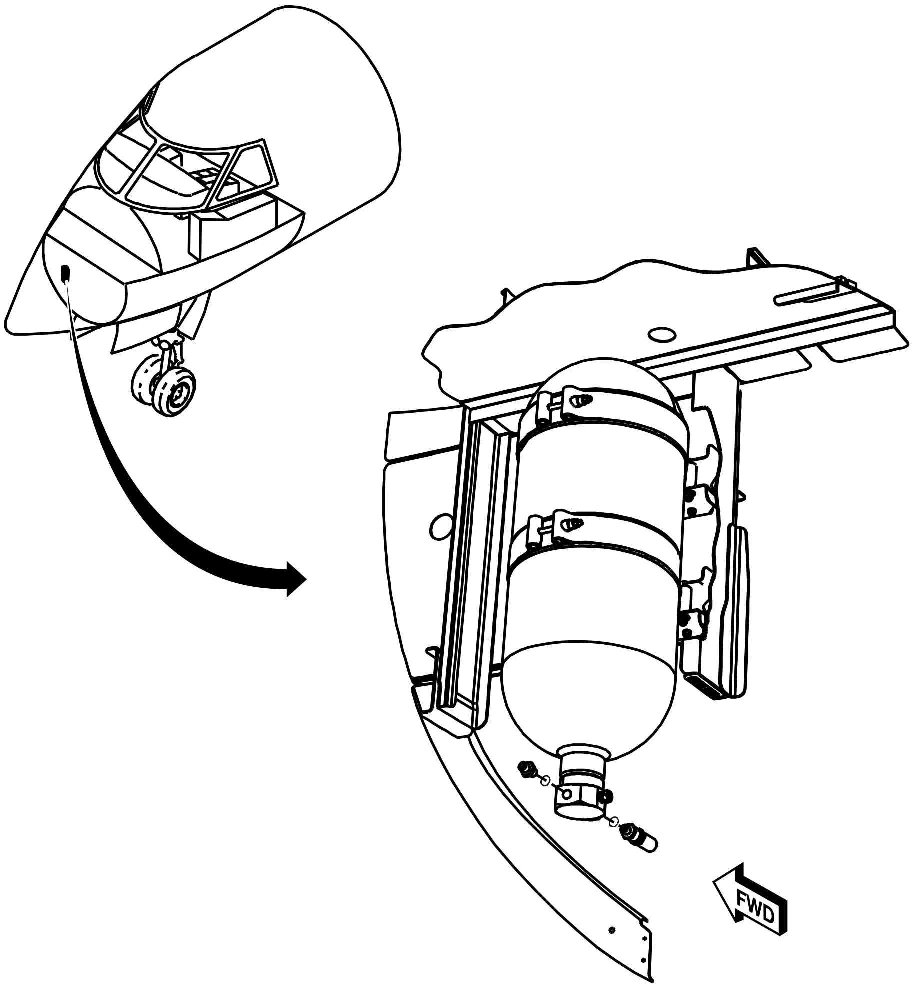

Figure 32-35. Nitrogen Storage Bottle

Nitrogen Storage Bottle

The emergency landing gear bottle, which is serviced with 3,100 psi dry nitrogen, is used to pneumatically extend the landing gear. The 400-cubic inch bottle is located on the right side in the nose wheel well (Figure 32-35).

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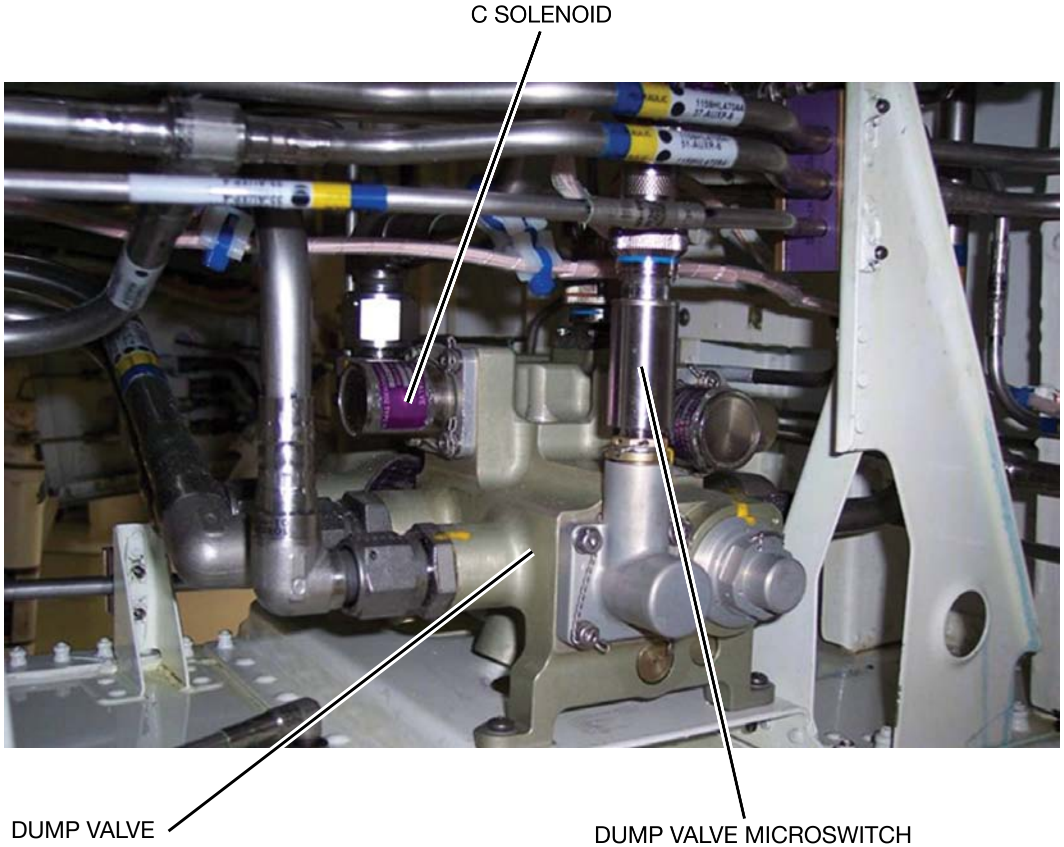

Figure 32-36. Selector Dump Valve

Selector Dump Valve

In addition to the selector/dump valve controlling the normal extension and retraction of the landing gear, the dump valve portion of the valve isolates the hydraulic system from the landing gear during emergency extend operation. It also provides a return fluid flow path from the landing gear components to the left hand hydraulic reservoir (Figure 32-36).

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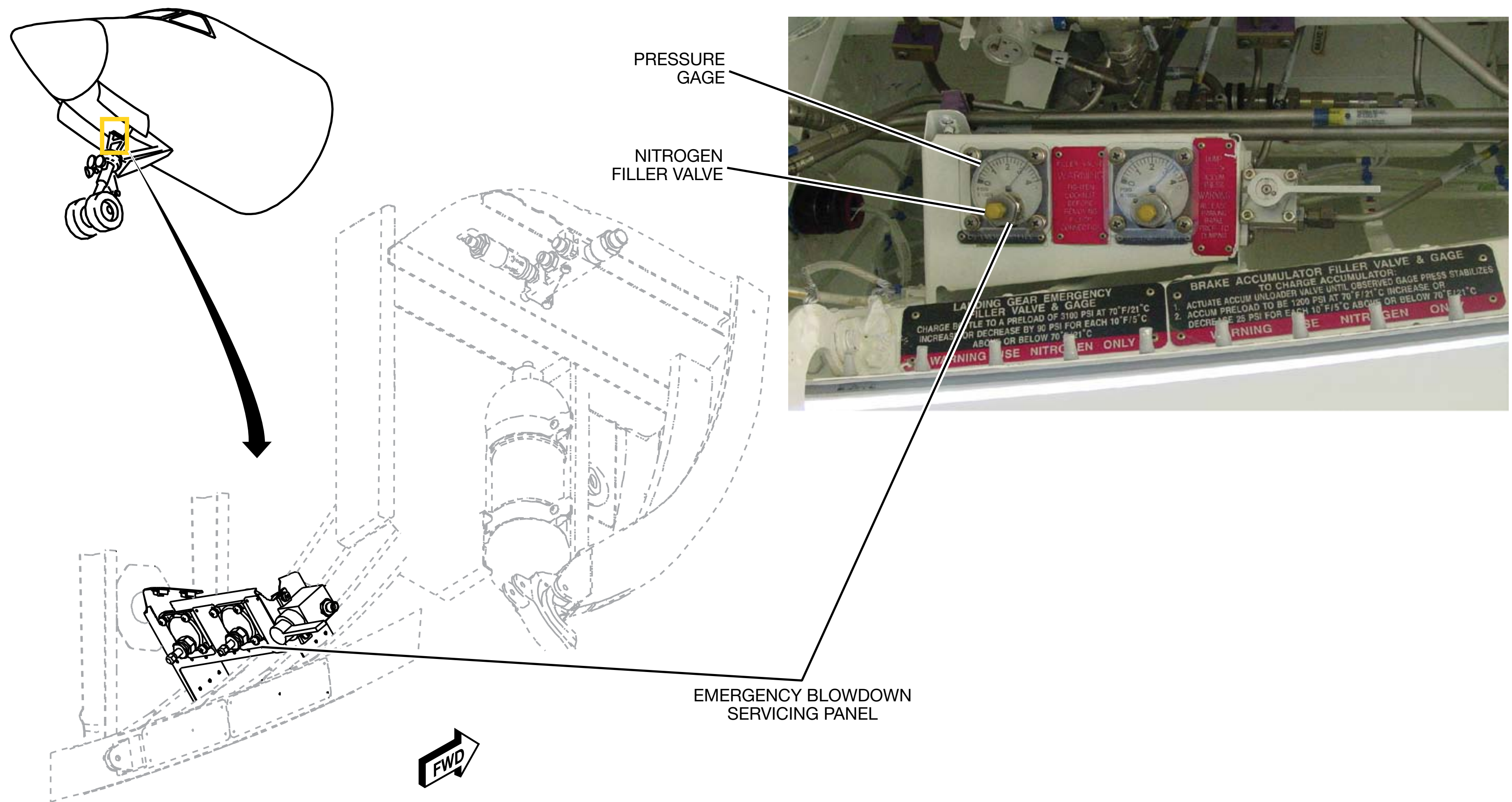

Figure 32-37. Emergency Blowdown Servicing Panel

Nitrogen Servicing Panel

The pressure gage for the emergency landing gear bottles is mounted on a service panel in the nose wheel well (Figure 32-37). The pressure gage is a direct-reading type. The gage indicates the pressure within the emergency landing gear bottles and should read 3,100 ± 50 psi with the bottles fully charged at 70°F. A nitrogen filler valve is mounted on the pressure gage. The servicing panel incorporates a check valve to prevent loss of cylinder pressure.

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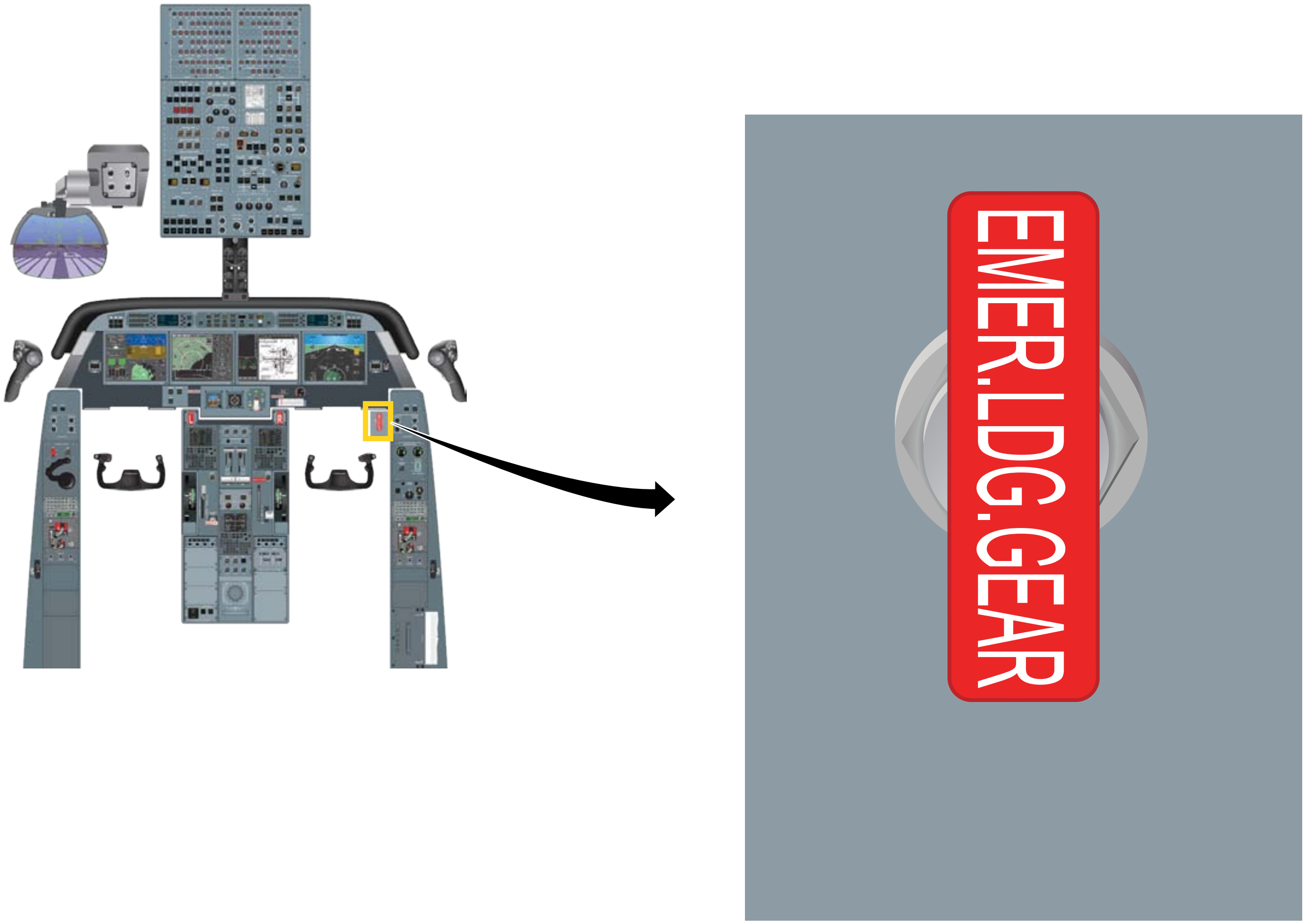

Figure 32-38. Emergency Extension Handle

LANDING GEAR EMERGENCY EXTENSION CONTROLS

Emergency Extension T-Handle

The emergency extension T-handle is located on the forward side of the copilot's side panel and initiates the landing gear emergency extension (Figure 32-38). It is a mechanical linkage that connects to the emergency extension air release valve.

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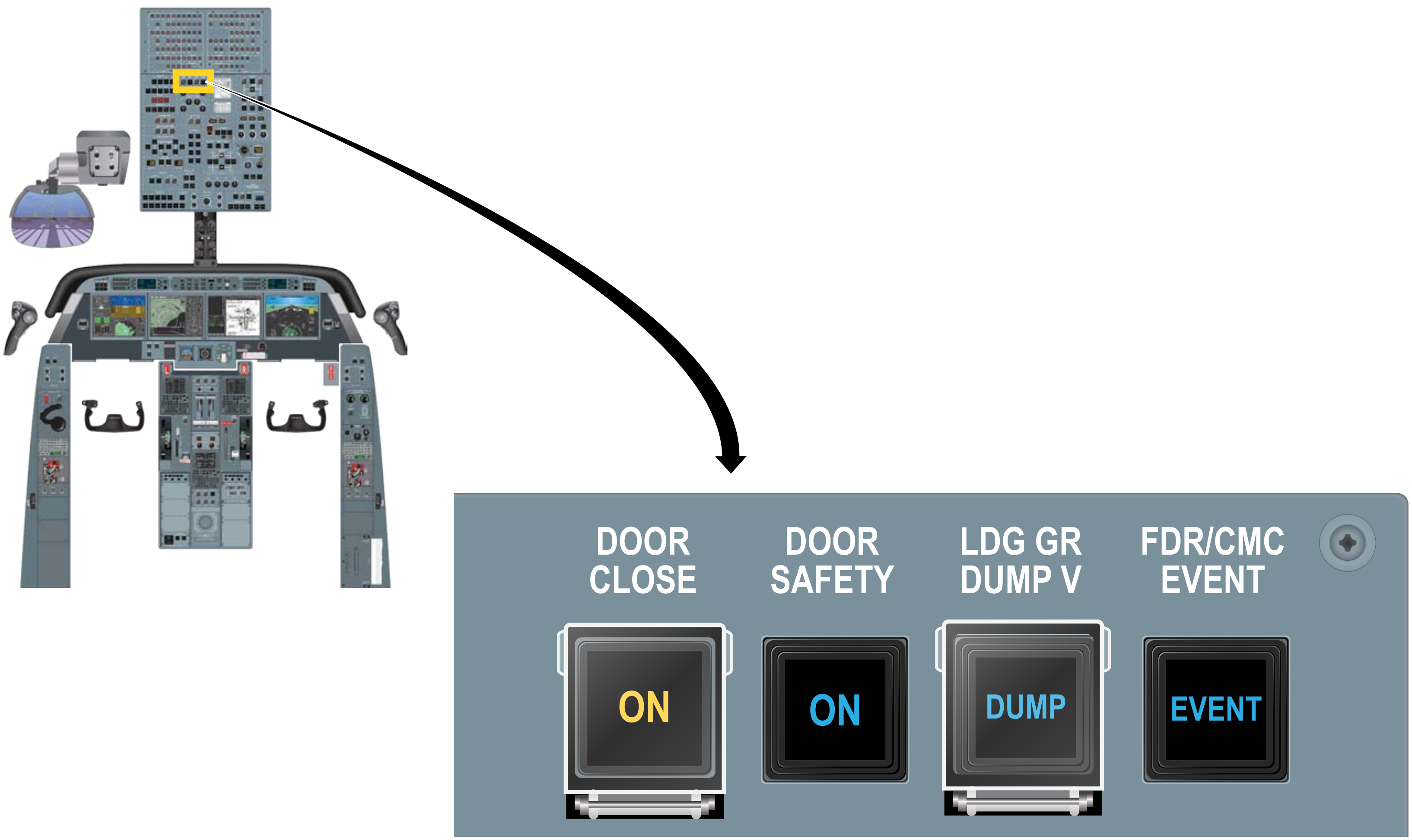

Figure 32-39. Dump Valve Reset Switch

Dump Valve Reset Switch/Indicator

A dump valve reset switch is located on the cockpit overhead panel and is used to electrically reset the dump spool valve after an emergency extension has been accomplished (Figure 32-39). The guarded switch light illuminates a blue “DUMP” legend when the gear has been extended pneumatically, and the light extinguishes when the dump valve has been reset.

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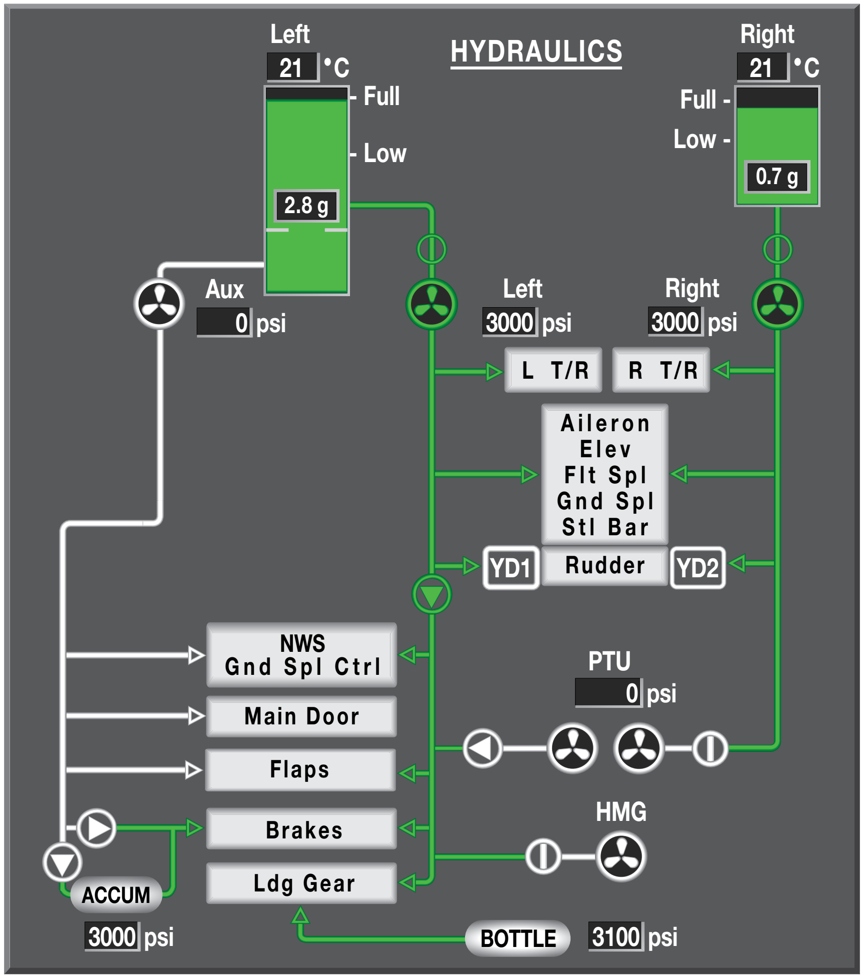

Figure 32-40. Emergency Blowdown Synoptic Page Bottle Pressure

LANDING GEAR EMERGENCY EXTENSION INDICATIONS

Storage Bottle Synoptic Page Indication

The nitrogen storage bottle pressure is displayed on both the hydraulic and summary synoptic pages (Figure 32-40). The displayed indication on either page will turn amber when the pressure is below 2,450 or above 3,520 psi. The pressure transmitter that is utilized for the synoptic display is mounted on the left side of the nose wheel well and linked into the servicing connection.

NOTES

NOTES

LANDING GEAR EMERGENCY EXTENSION OPERATION

Emergency Gear Extension

The emergency landing gear extension system is a backup system which is used when normal landing gear extension cannot be accomplished with either the left hydraulic system or the power transfer unit (see *MSM* Figures 32-6 and 32-7). Emergency landing gear extension is accomplished by pulling the emergency landing gear T-handle, located on the copilot's side console. A cable connects the emergency landing gear handle to the emergency extension air release valve.

The pressurized nitrogen then flows from the inlet port to the outlet port (the vent port of the valve is now closed), actuating the dump valve portion of the landing gear control valve and isolating the landing gear from the hydraulic system. This action prevents hydraulic system pressure from entering the landing gear system, as the up and down selector valve pressure ports are blocked. At the same time, the return port is open, permitting a direct path for fluid displaced by the nitrogen pressure to return to the left reservoir. Pneumatic pressure is also supplied directly to the unlock port of the landing gear uplock actuators, the open port of all three door actuators, and the extend side of the gear actuators, enabling the landing gear to extend.

NOTES

Emergency Gear Extension (Cont)

Total action of an emergency extension takes approximately six seconds. With the gear down and locked, the door-closing sequence is bypassed, and all landing gear doors remain open.

As long as the emergency landing gear T-handle is left in the extended position, nitrogen pressure remains in the actuators of each gear. If the T-handle is returned to the stowed position by pushing the handle slightly forward out of the detent position and fully down, the nitrogen pressure is released from the actuators and exhausted overboard through a vent on the right side of the nose wheel well.

Actuation of the dump valve causes the valve position switch to make contact and illuminate the LDG GR DUMP V switch with a blue “DUMP” on the cockpit overhead panel. Repositioning the dump valve to normal is accomplished by applying left or PTU hydraulic pressure, and then momentarily depressing the LDG GR DUMP V switch, which provides electrical power to a solenoid that repositions the valve and extinguishes the DUMP legend.

NOTES

Figure 32-41. Brake Maximum Performance Testing

Figure 32-42. Brake Maximum Performanc Skid Marks Below 10 Knots

BRAKE SYSTEM

BRAKE SYSTEM DESCRIPTION

This chapter will cover various operations and components of the brake actuation system to include:

- ABS Brake System
- Park / Emergency Brake System
- Brake Temperature Monitoring System

The braking system utilizes direct mechanical movements of the toe brake pedals to the brake metering valves. The brake metering valves convert a mechanical input into a hydraulic signal. The Dual Skid Control Valves (DSCV) only provide a path for flow of the fluid unless there is a skid condition. The fluid then travels through the brake fuses, transmitters, shuttle valves and eventually to the brakes for actuation (Figure 32-41).

Acceptable operation of the anti-skid system is defined as that which allows the crew to rapidly apply and maintain maximum brake pressure to a complete stop without blowing the tires (Figure 32-42).

The brakes, wheels, digital anti-skid control unit, and brake temperature monitoring sensors are provided by ABSC (Aircraft Braking System Corporation) located in Akron, OH.

The major components within the system are:

- Brake pedals
- Brake metering valves
- Dual Skid Control Valves (DSCV)
- Brake fuses
- Brake pressure transducer
- Main wheel brake assembly
- Wheel speed sensor
- Brake temperature monitoring sensor
- Digital anti-skid control unit

NOTES

Figure 32-43. Rudder Pedals

BRAKE SYSTEM COMPONENTS

Brake Pedals

Purpose

The brake pedals provide independent control of on strut brake pressure and force feedback to either pilot or copilot.

Location

The brake pedals are incorporated into the tops of the rudder pedals for both the pilot and copilot (Figure 32-43).

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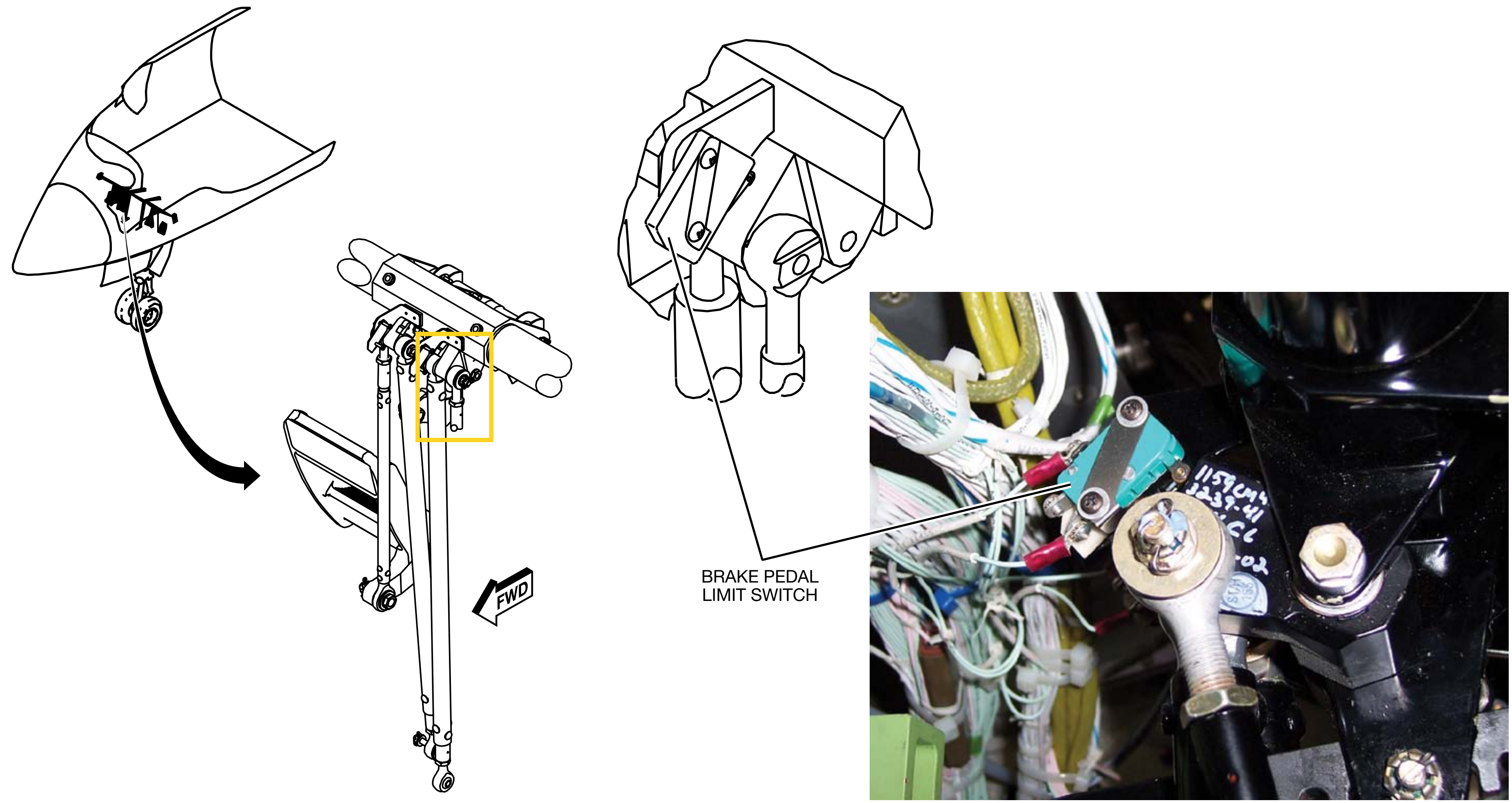

Figure 32-44. Brake Pedal Switch

Brake Pedal switch

Location

The brake pedal micro switches are attached to the Pilots left and right brake pedals (Figure 32-44).

Purpose

In the event of a loss of left hand and PTU hydraulic pressure, when the Aux system is armed, the brake pedal micro switches work in conjunction with the Auxiliary Hydraulic pressure switch. When the brakes are depressed greater than 10 º, the Auxiliary pump will activate to provide braking pressure to the system.

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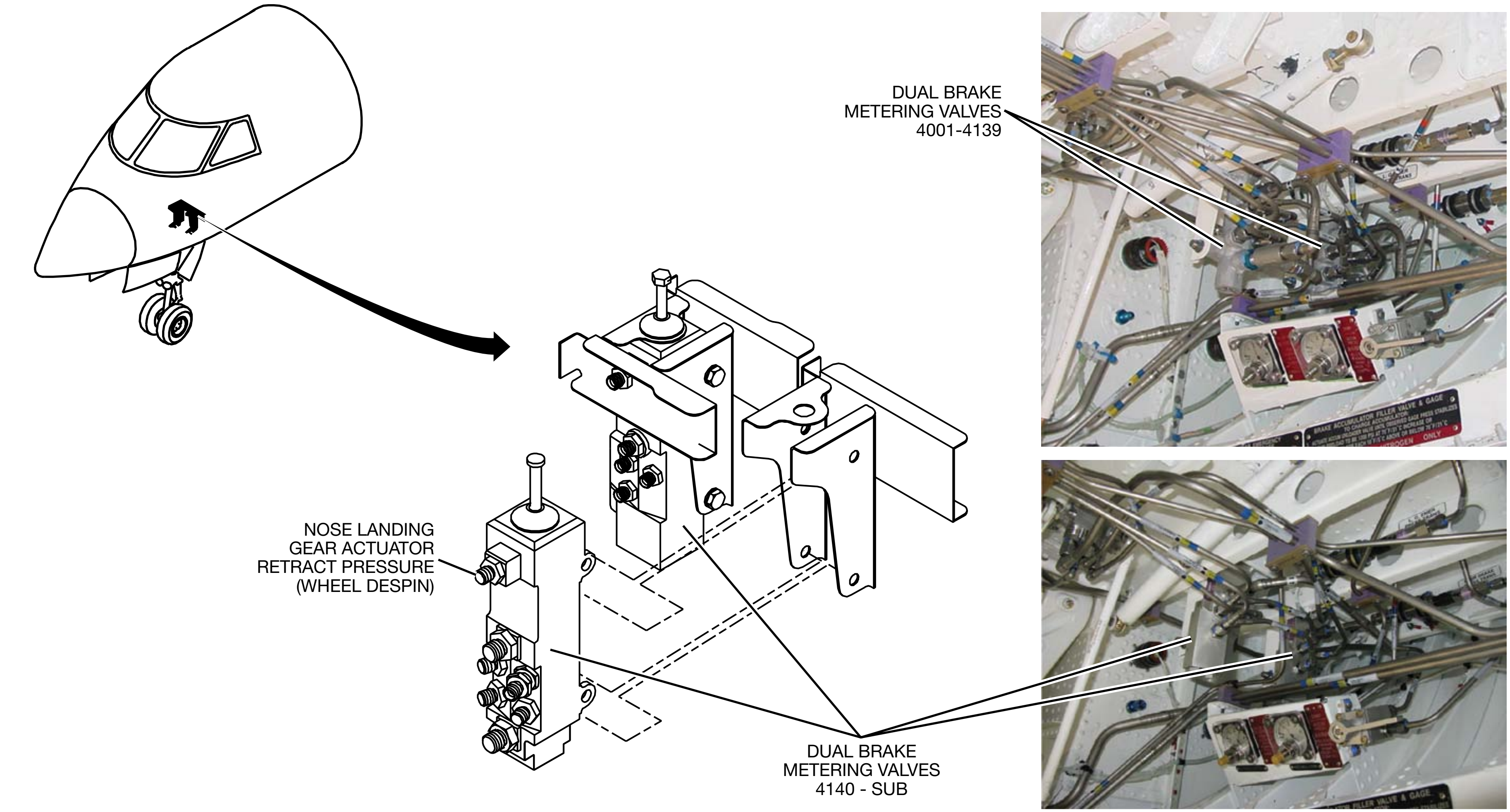


Figure 32-45. Dual Brake Metering Valves

Dual Brake Metering Valves

Purpose

The brake metering valves are designed to meter hydraulic pressure in proportion to the force applied manually to either pilot or copilot toe brake pedals (Figure 32-46).

Location

The brake metering valves are located side by side, just forward of the nose wheel trunnion, left hand side, in the nose wheel well (Figure 32-45).

On aircraft SNs 4001–4139 with ASC 50 and aircraft 4140 and subsequent, the P/N 1159SCH528 dual brake metering valves, P/N 1159SCH223 brake shuttle valves and associated plumbing have been removed and replaced with PN 1159SCL473-3 dual brake metering valves and modified plumbing.

The P/N 1159SCL473-3 dual brake metering valves incorporate an integral shuttle valve and revised spool design which will eliminate pressure over-shoots, reduce internal friction, oscillation and delay. Movement of the shuttle valves eliminate the requirement for separate assemblies. This service change was designed to improve the aircraft braking characteristics during taxi and anti-skid conditions. The dual brake metering valves have been redesigned to eliminate sensitive behavior of the brake control system characterized by sudden clamp-up (grabby brakes).

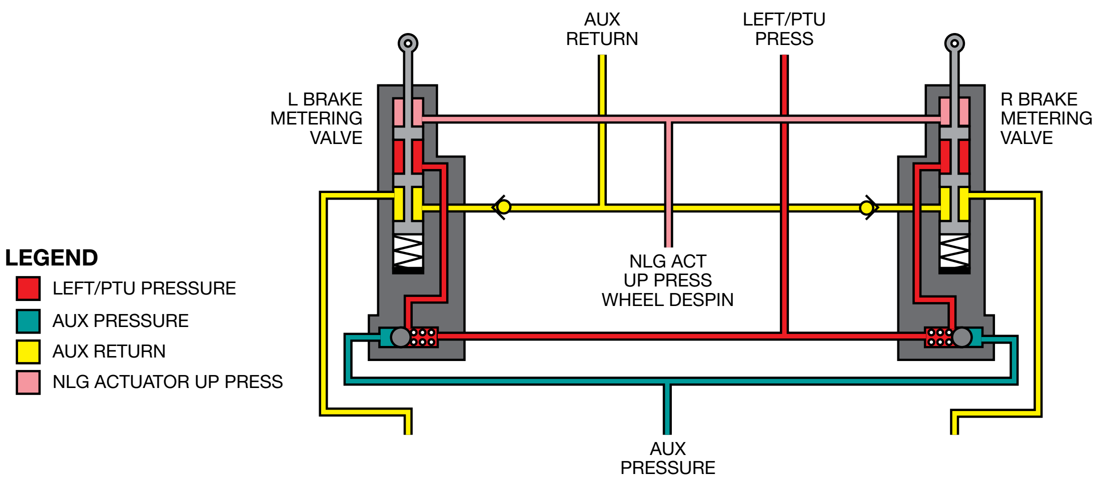
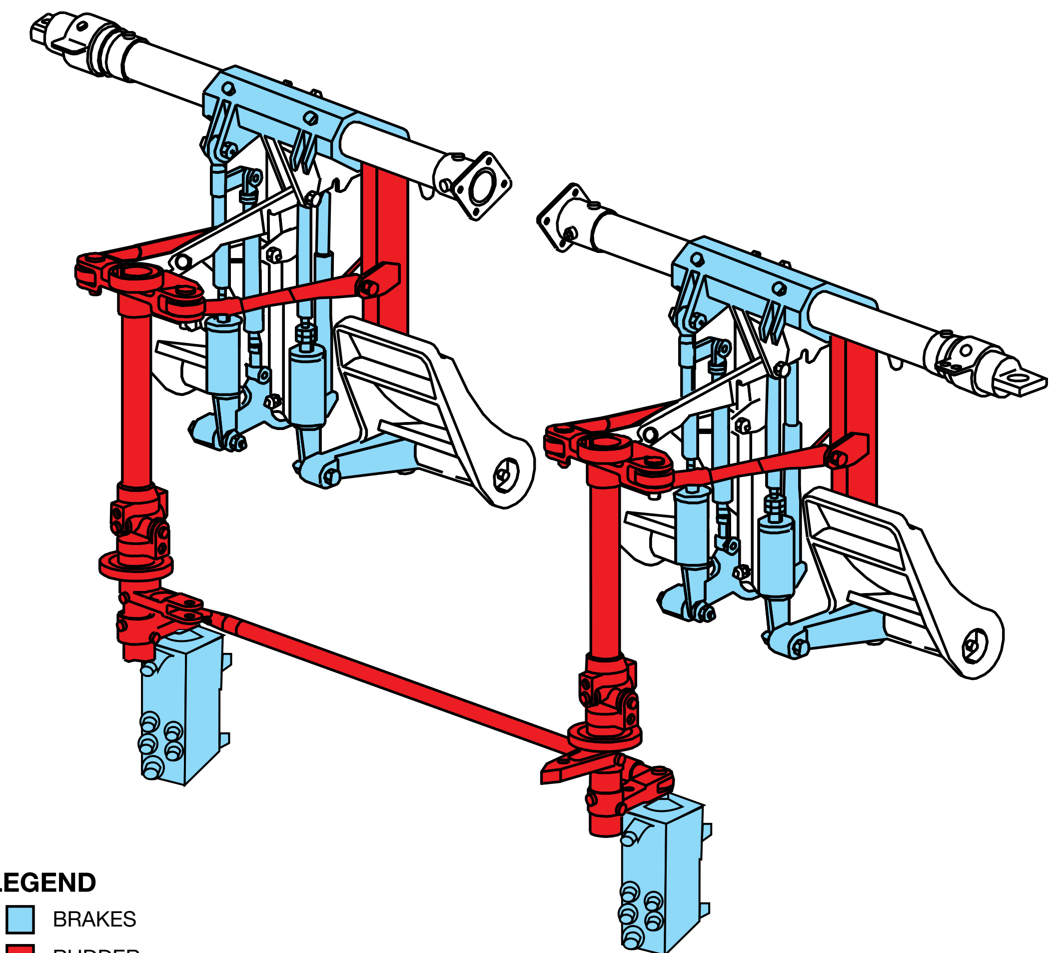


Figure 32-46. Brake Metering Valve Schematic



LEGEND

- BRAKES
- RUDDER

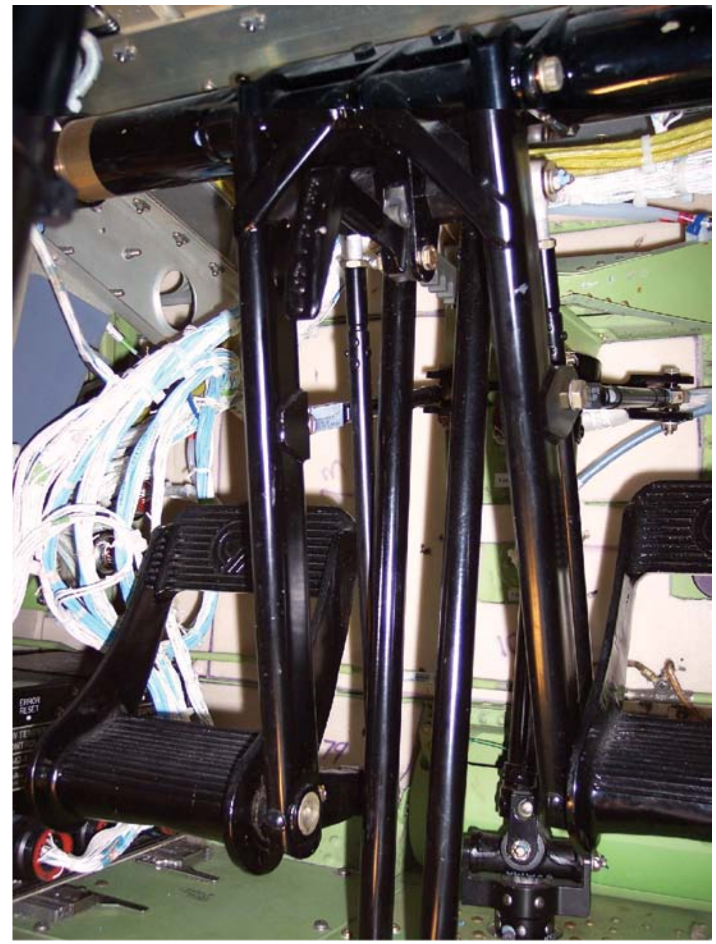


Figure 32-47. Rudder Pedals and Brake Pedal Linkage

Operation

There are two brake metering valves, one for the left brakes and one for the right brakes. The brake metering valve provides a pedal force proportional to brake pressure with an assortment of springs and a pressure regulator valve assembly.

The brake metering valve combines three pressure signals, left PTU systems, auxiliary hydraulic systems, and wheel despin on a tandem spool and sleeve arrangement. The left system and PTU systems utilize the same hydraulic lines attached to the metering valves. The auxiliary system pressure lines are separate and include shuttle valves to isolate it from the left and PTU common system lines. The wheel despin hydraulic lines are attached to the nose landing gear retract actuator and require no pilot input to operate the metering valves on gear retraction (Figure 32-47). If there is a failure of one of the hydraulic pressure sources the other systems are designed to automatically take over operation.

If the left system pressure drops below 1500 psi (as identified by the pressure switch on the left system hydraulic manifold), and the PTU is armed, brake pressure will automatically transfer to the PTU. If the left and PTU pressure is below 1500 PSI, AUX system is armed and one of the brake pedal switches are activated the AUX system will then supply pressure to the brakes. No crew action is required for the transfer, and the system uses the same brake system components.

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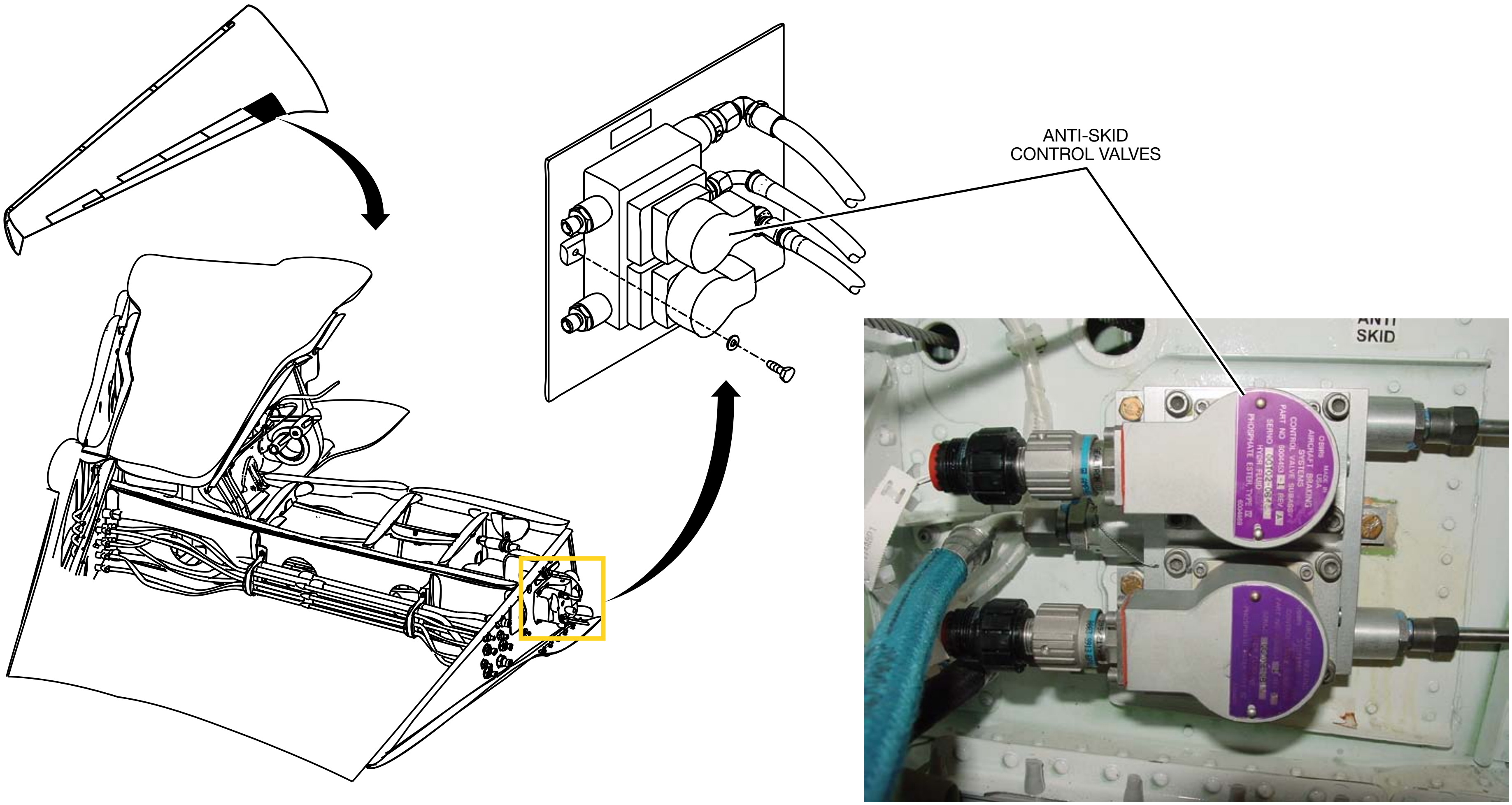

Figure 32-48. Anti-Skid Control Valve

Anti-Skid Control Valve

Purpose

The Anti-skid control valves are designed to reduce the hydraulic brake pressure to a level below that metered by the pilot whenever a skid begins to develop.

Location

The system consists of two skid control valve assembly modules. Each module contains two anti-skid control valves and are located in each trailing edge box (main wheel well) (Figure 32-48).

Operation

Each Anti-skid control valve contains two, two stage pressure control servo valves. A single hydraulic pressure input from the brake metering valves is divided into an, inboard and outboard brake pressure for each main gear The servo valves are independently controlled by the digital anti-skid control unit based on inputs from the wheel speed sensors. The anti-skid two stage servo valves and DACU provide initial variable release rates of the brake pressure. This release rate is tunable within the DACU based on engineering requirements.

Both anti-skid control valves contain a 15 micron absolute inlet filter and return pressure is through an aux system return line.

For full brake release, 25 ma is supplied by the DACU, otherwise 5 ma is supplied to the servo valves ensuring that the brake pressure is equal to the metered pressure when no skid relief is required.

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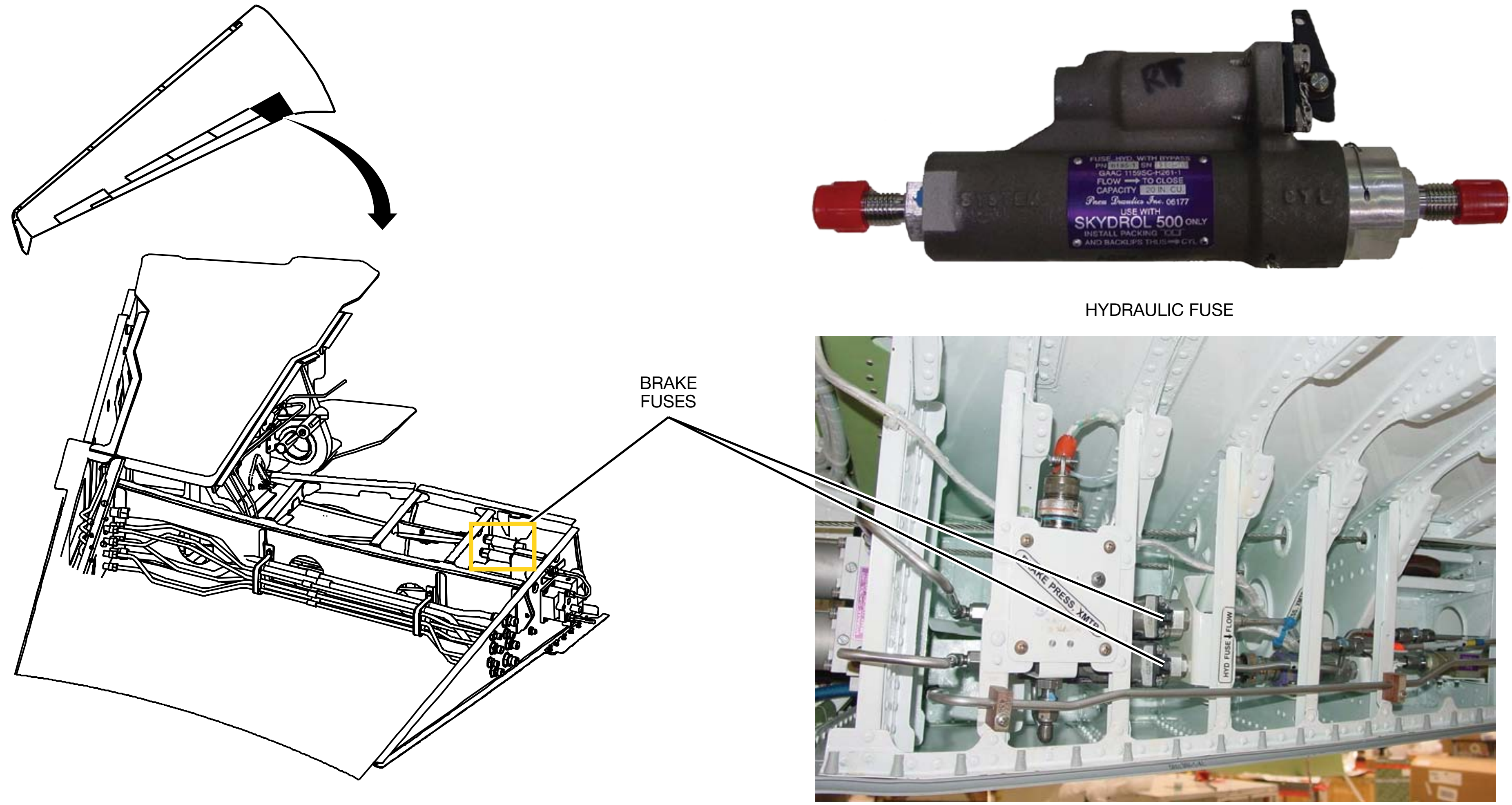

Figure 32-49. Hydraulic Brake Fuses

Brake Fuses

Purpose

In the event of a hydraulic rupture downstream of the fuse, the brake fuse is designed to limit hydraulic fluid loss.

Location

There are four normal system brake fuses, one for each brake assembly. They are located in the primary brake system fluid lines and located in the trailing edge wing boxes, accessed from the main landing gear wheel wells (Figure 32-49). The parking brake / emergency brake system also has brake fuses located left and right of the MLG door control valve.

Operation

The brake fuse is a volumetric type fuse with a manual bypass function. A flow greater than 4-6 cubic inches will set the fuse and prevent fluid loss. A bypass lever is incorporated into the fuse for maintenance purposes to bypass the fuse while bleeding air from the brake hydraulic lines.

NOTES

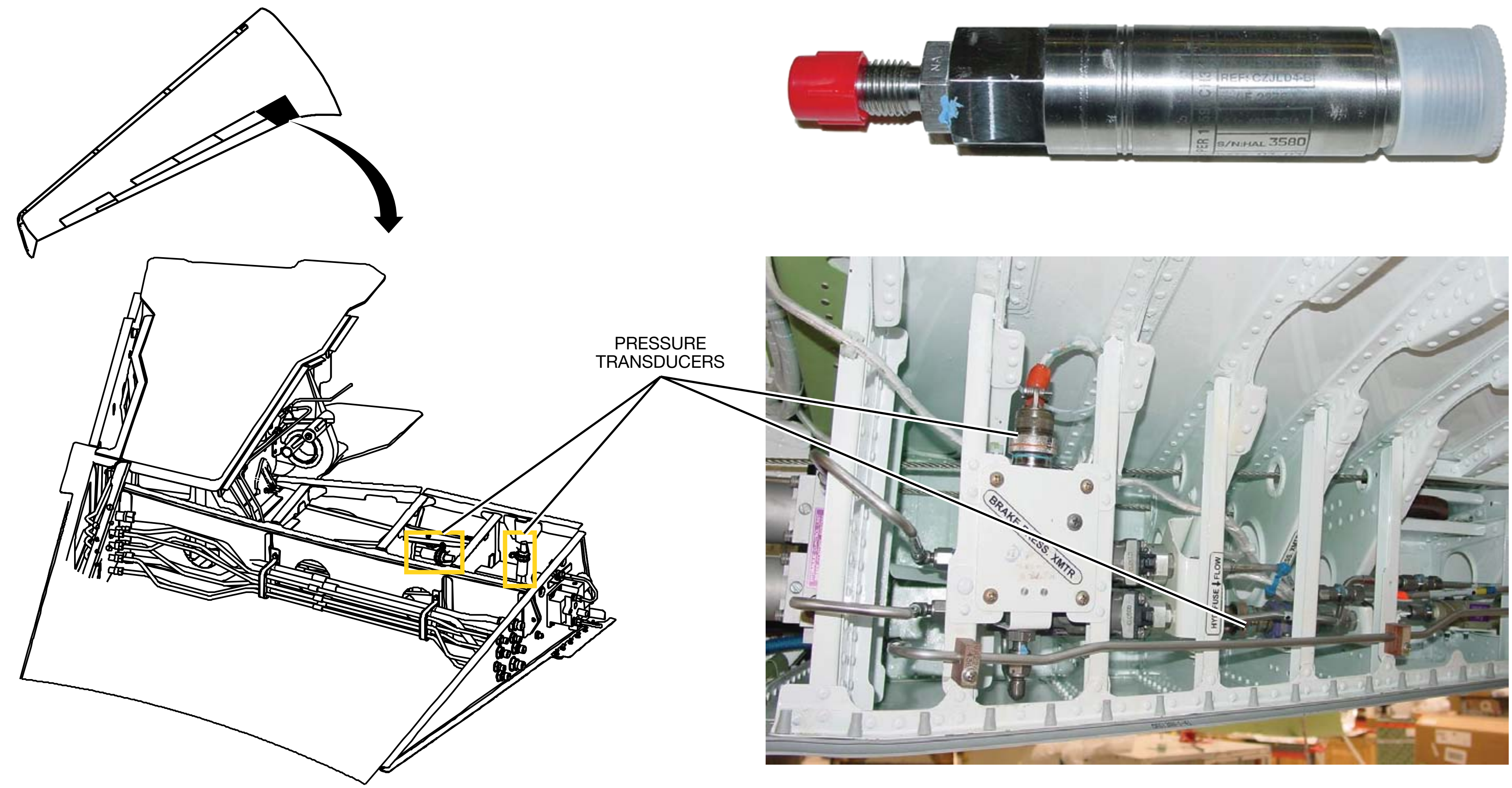

Figure 32-50. Brake Pressure Transducers

Brake Pressure Transducer

Purpose

The transducers are designed to give brake pressure indications to the MAUs. The pressure will be converted to a bar graph indication for cockpit brake synoptic display.

Location

The pressure transducers are located in the trailing edge of the wing just after the brake fuses (Figure 32-50). The left outboard and right inboard pressure transducers are also utilized to transmit applied parking / emergency brake pressure via shuttle valves.

Operation

The pressure transducers receive power from the left essential 28VDC bus via the APPLIED BRK PRESS circuit breaker. Pressure variances change the voltage output, which the MAUs convert the 0–5VDC to a displayed pressure to the door.

- Left Pressure Transducers—DGIO 1 MAU 1
- Right Pressure Transducers—DGIO 2 MAU 2

NOTES

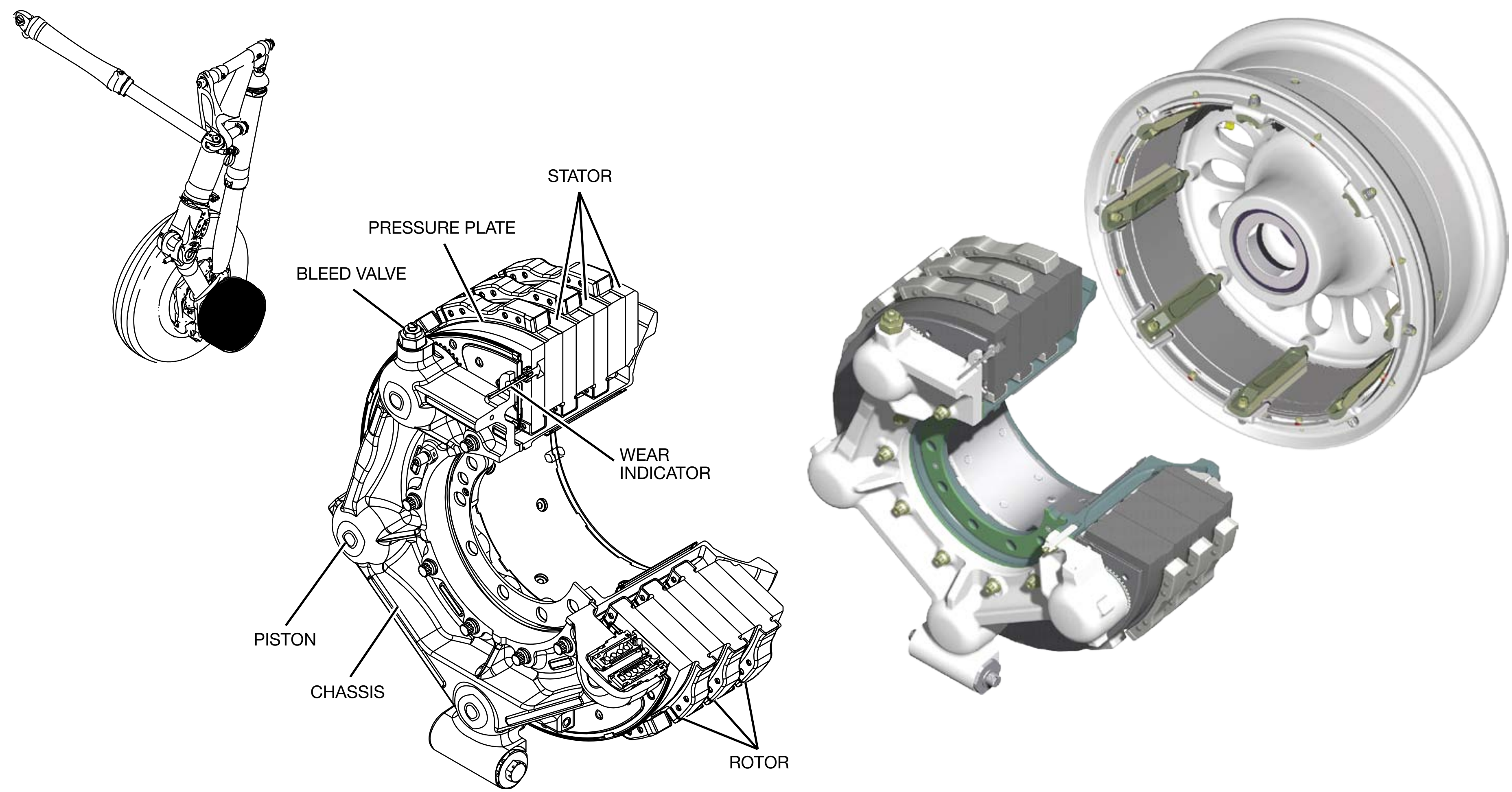

Figure 32-51. Main Wheel Brake Assembly (ABS)

Brake Assembly

Purpose

The brakes are designed to slow the rotation of the main wheels for deceleration of the aircraft on landing rollout.

Location

The brakes are located on either side of the MLG strut assemblies, secured to the axle torque flange by bolts, washers and nuts.

Operation

Each of the main wheels are equipped with ABSC carbon brake assemblies. Each brake heat pack contains three rotating disks, which are keyed to rotate with the wheel and four stationary disks which are keyed to torque tube of brake (Figure 32-51).

The brake housing contains five cylinders which are interconnected to bleeder ports and a shuttle valve housing, which is integral to the brake housing. Each brake has two bleeder ports which permit the brake to be used interchangeably for right or left hand installation on the aircraft.

Braking action is produced by hydraulic pressure forcing five pistons against the pressure plate, which in turn, forces the disc stack together creating friction between rotating and stationary discs. When hydraulic pressure is released, five sets of return springs and their return pins pull the pistons to their off position, allowing the discs to release and the wheel to rotate freely.

Self adjusting piston mechanisms are incorporated in each brake cylinder assembly to maintain a constant brake clearance as the brake carbon disks wear away. A brake wear indicator pin is provided in each brake assembly to determine brake wear. Heat pack wear is measured by the amount of indicator pin protruding through a brake housing flange when the brakes are pressurized to 300 PSI. When the wear pin is flush with the brake housing flange, the heat pack is considered fully worn and beyond use.

The heat pack is changed by removing the eight bolts that hold the brake housing assembly to the axle. The brake housing is attached to the toque block by ten bolts of which two are hollow to facilitate installation of one brake temperature sensor.

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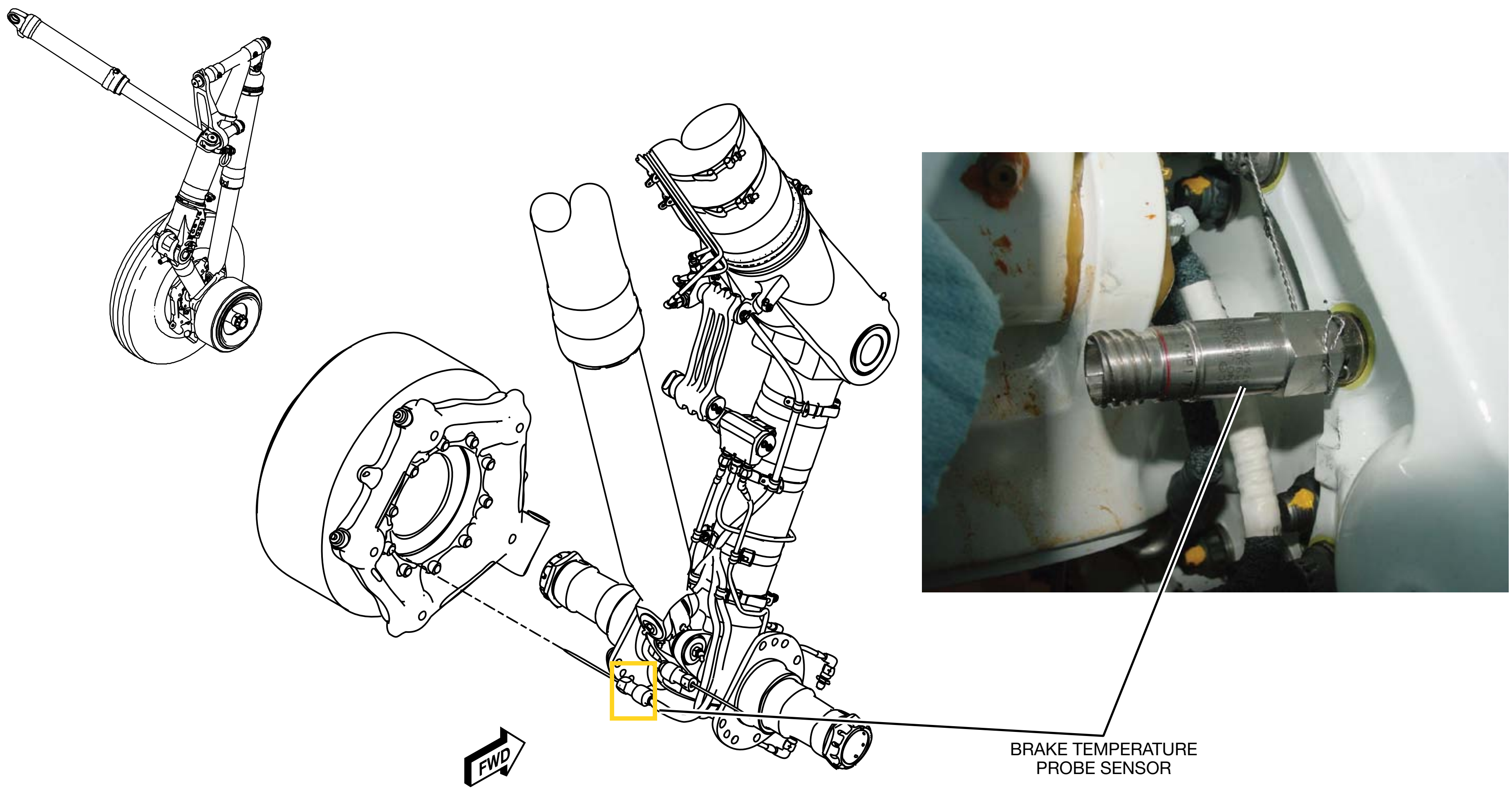

Figure 32-52. Brake Temperature Probe Sensor

Brake Temperature Monitoring Sensors

Purpose

The braking system is designed to convert braking energy into heat energy. The aircraft provides a means to monitor the brake temperature.

Location

A sensor is located on each main wheel brake. The sensor is a K-type thermocouple providing a null current voltage to the Digital Anti-Skid Control Unit (DACU).

Operation

The digital anti-skid control unit monitors data from four wheel brake temperature sensors. The Digital Anti-Skid Control Unit (DACU) processes the voltage and reports individual digital readings of brake temperature over the ARINC 429 bus. The brake temperature is displayed on the brake synoptic page as four individual bar graphs for each corresponding wheel. The brake system page also includes a peak temperature display. The DACU is capable of determining if a short exists in the system. The DACU will activate the "Brake Temp out of Limits" when the temperature split between the brake assemblies on a single strut reach a predetermined difference.

K-Type Thermocouple

The brake temperature sensor is a thermocouple which is based on the principle that when two dissimilar metals are joined a predicvoltage will be generated. The sensor is a flexible probe which is installed into a modified bolt. The flexibility of the sensor allows its removal from the brake housing bolt without having to remove the brake assembly.

The K-Type thermocouple utilizes chromel as the anode (+) and alumel as the cathode (-) with a temperature range of 0-1260°C (32-2300°F) (Figure 32-52).

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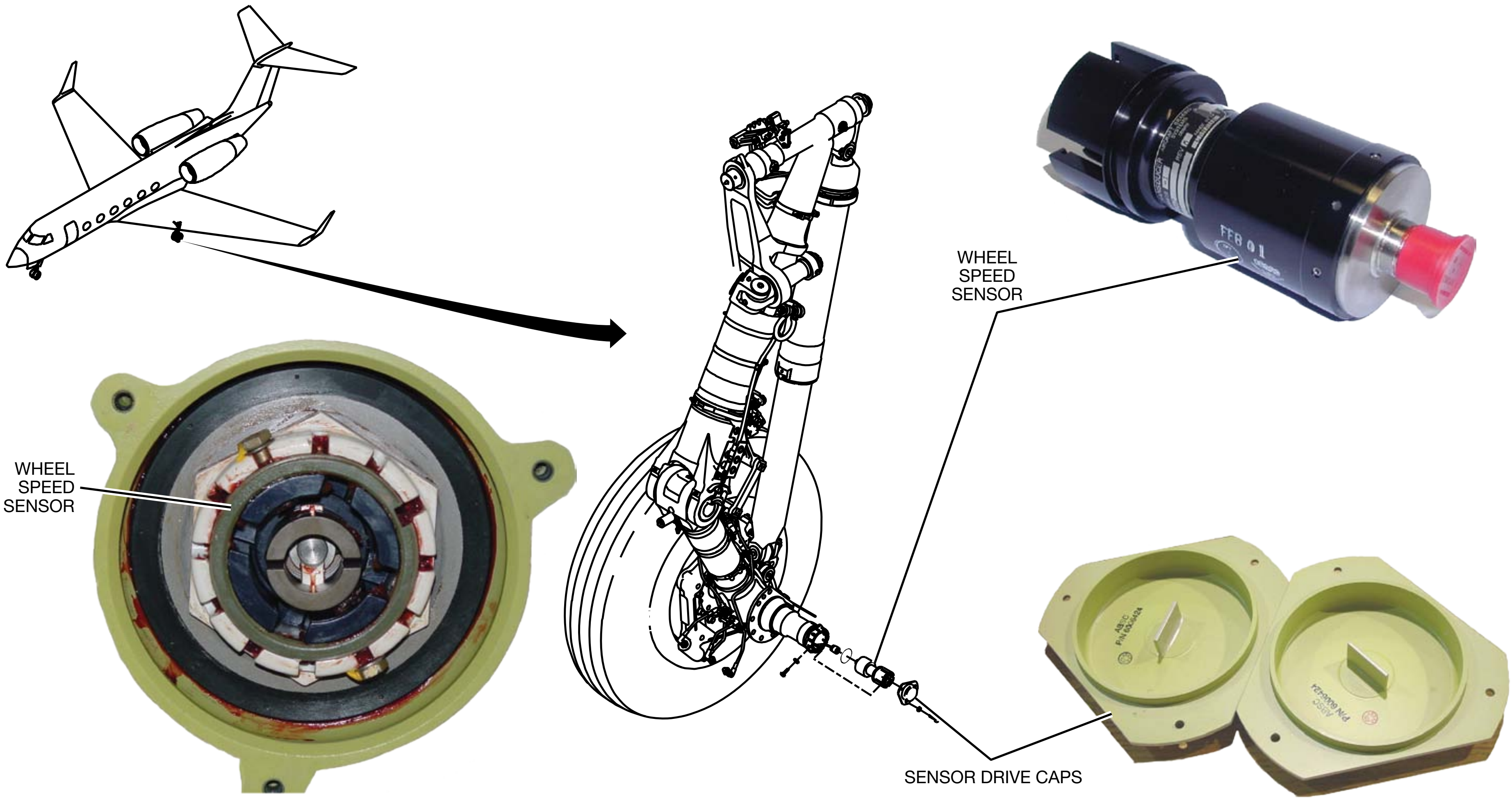

Figure 32-53. Wheel Speed Sensor

Wheel Speed Transducer

Purpose

For skid detection, wheel speed sensors are used to sense the rate of change of wheel speed.

Location

The wheel speed sensors, of which there are four, are mounted in each end of the main landing gear axles and are driven by drive caps (couplings) in the wheel hubcaps (Figure 32-53).

Operation

All wheel speed sensors are driven at a 1:1 ratio producing 100 pulses per rotation. Rotation of the wheel speed sensors produces an output signal proportional to wheel speed. The DACU detects wheel deceleration and compares rate of change of wheel speed with normal aircraft deceleration and transmits signals to the control valves to effect brake pressure correction.

The drive cap has an integral drive blade inside which mates with the coupling on the sensor shaft. The drive cap is attached to the outboard wheel half hub with bolts.

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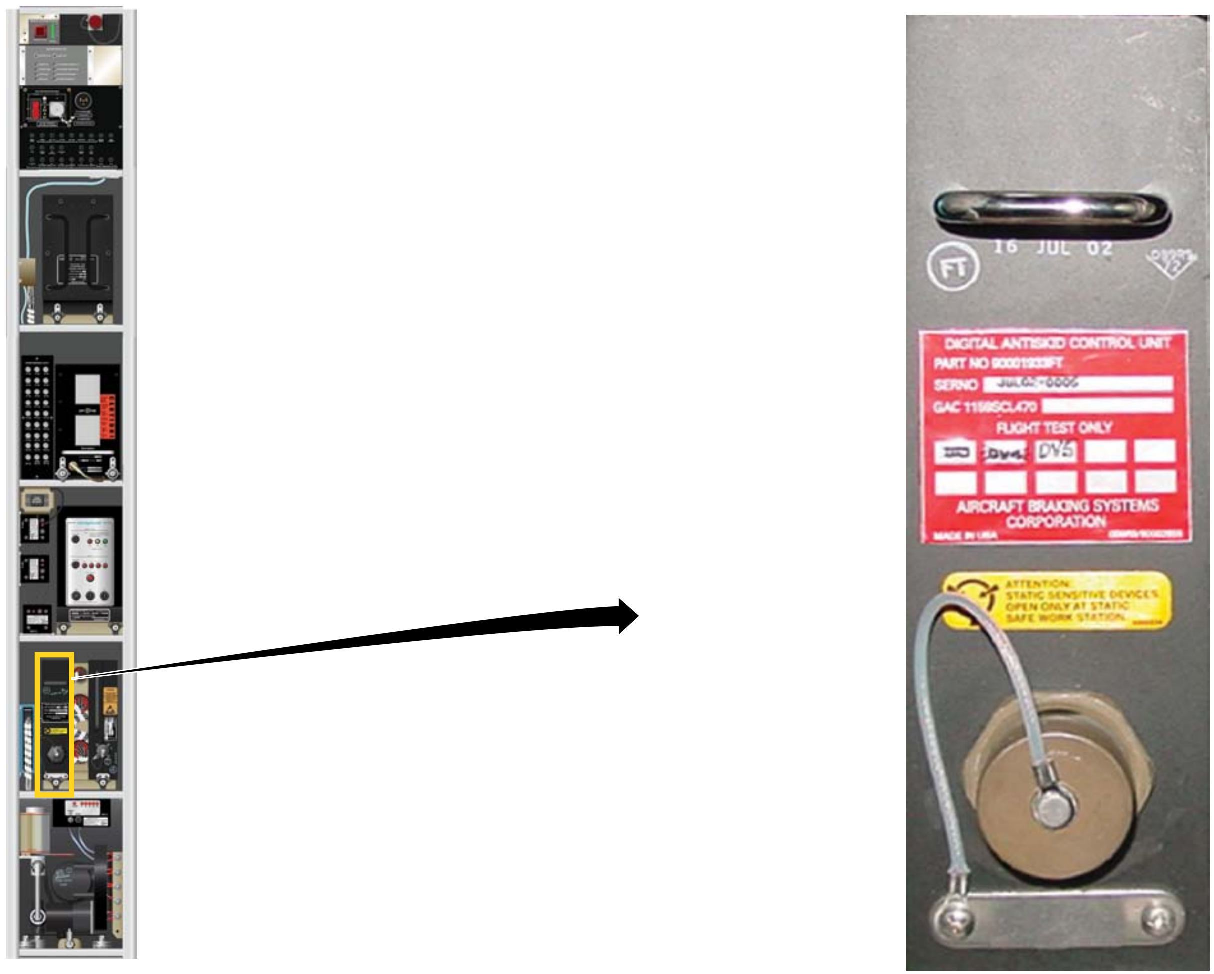

Figure 32-54. Digital Anti-Skid Control Unit

BRAKE SYSTEM CONTROLS

Digital Anti-Skid Control Unit (DACU)

Purpose

The DACU combines wheel spin-up, brake temperature processing and individual anti-skid control for each of four wheels into one LRU. Additionally, the DACU provides touchdown protection, locked wheel protection, and controlled wheel de-spin during gear retraction. Primary anti-skid protection is available at aircraft ground speeds down to 10 knots. The DACU provides continuous self-monitoring, and built-in-test. All DACU outputs are reported over the ARINC 429 bus.

Location

The DACU is located in the baggage electronic equipment rack, on the second shelf from the bottom (Figure 32-54).

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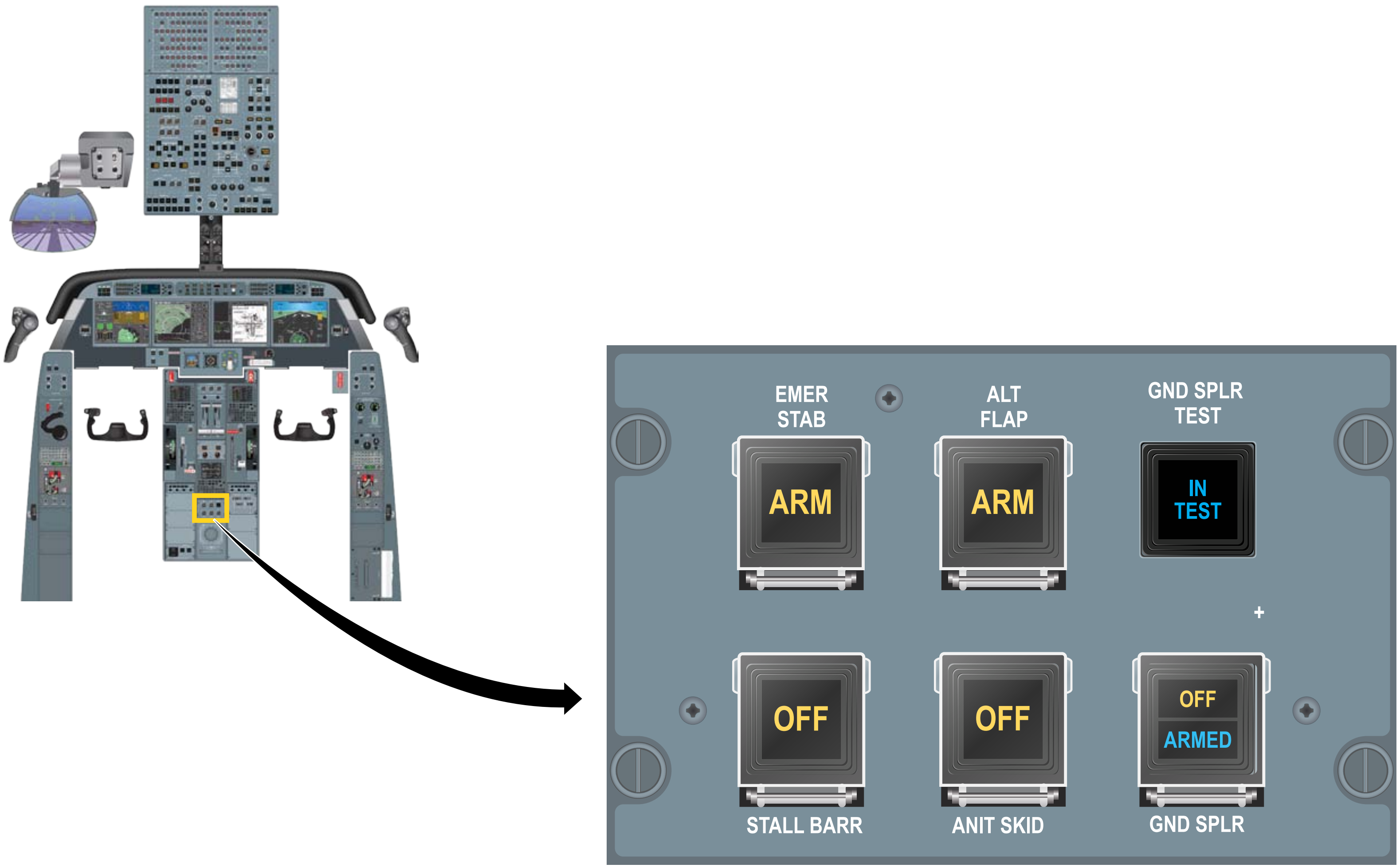


Figure 32-55. Anti-Skid Control Switch

Digital Anti-Skid Control Unit (DACU) Operation

The skid control box receives signals from the wheel speed sensors and in turn transmits controlling signals to the dual-skid control valves, which regulate the brake pressure. The DACU also processes the null current voltage of the brake temperature probes and reports individual digital readings of brake temperature over the ARINC 429 bus.

The DACU is a sealed unit with two independent circuit cards which control anti-skid operations for the brakes. Each circuit card performs anti-skid operation for a pair of wheel brake assemblies. The wheel brakes are paired as inboard or outboard wheel sets. The left inboard and right inboard wheel anti-skid is controlled by one of the DACU circuit cards, and the outboard wheel brakes with the second DACU circuit card. If a single anti-skid circuit card fails the remaining circuit card is still capable of operating independently on the remaining wheel pair. Brake temperature is always available even with a failed circuit card, since it is a redundant function on each circuit card.

- Inboard Brakes Circuit Card (L ESS DC)
- Outboard Brakes Circuit Card (R ESS DC)

The interface with the DACU is through the CMC. A single cannon plug connection is available on the front panel of the DACU for ABSC use only. The anti-skid system can be turned off by a switch located on the center pedestal (Figure 32-55).

DACU Inputs

The DACU inputs are:

- WOW
- Gear handle
- On/Off switch
- Wheel speed transducers
- Brake temperature probes
- ARINC 429

DACU Outputs

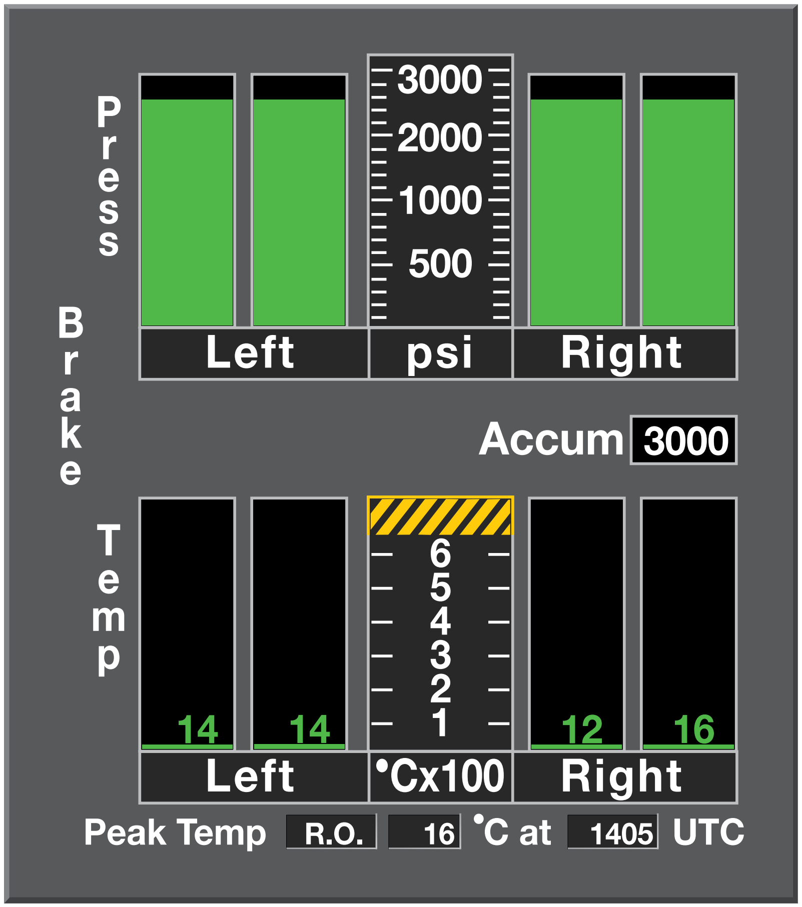
The DACU outputs are:

- Brake temp
- Ground spoiler and T/R discrete
- 5 or 25 ma
- ARINC 429

DACU Modes of Operation

The DACU modes of operation are:

- Touchdown protection
- Locked wheel protection
- Anti-skid protection
- Controlled wheel spin down
- Built In Test (BIT)



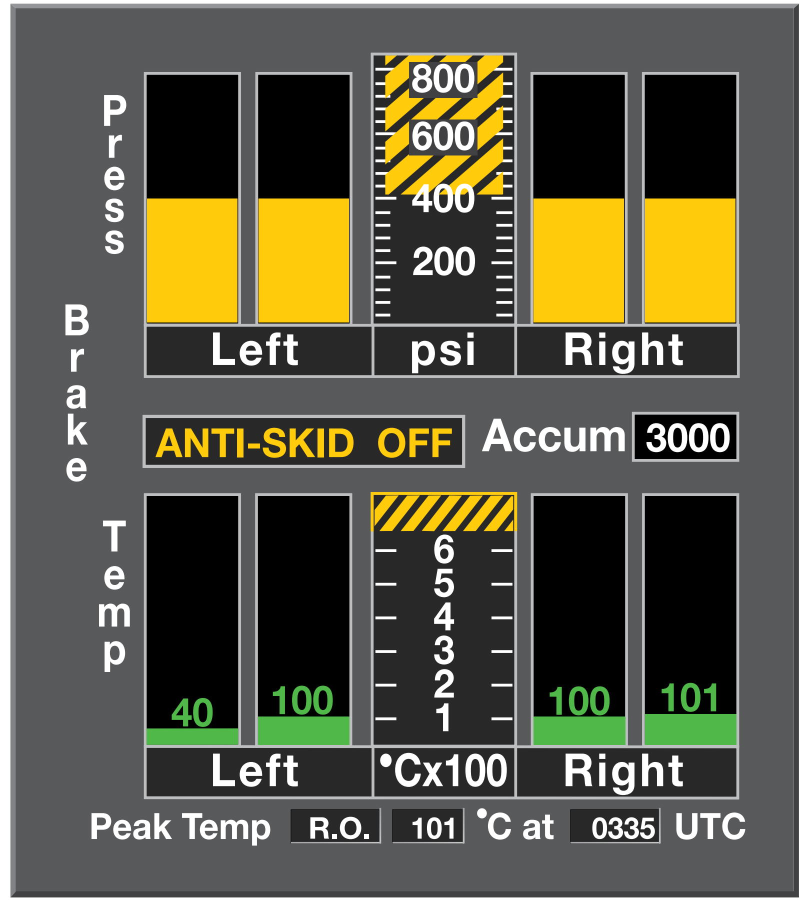


Figure 32-56. Brake Synoptic Pages

BRAKE SYSTEM INDICATIONS

Synoptic Pages

Synoptic pages for the brakes are shown in normal and anti-skid selected off/fail (Figure 32-56).

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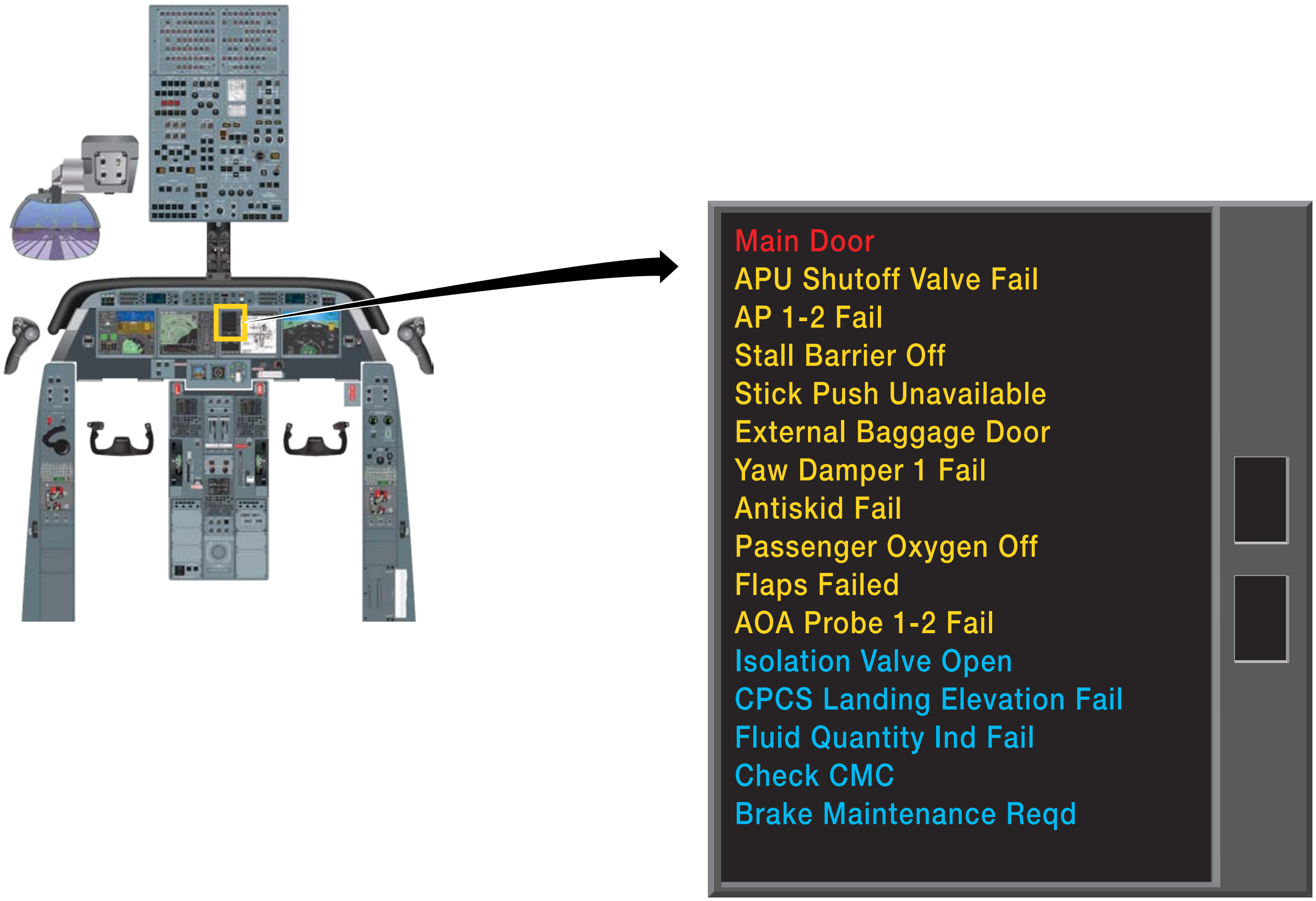


Figure 32-57. CAS Messages

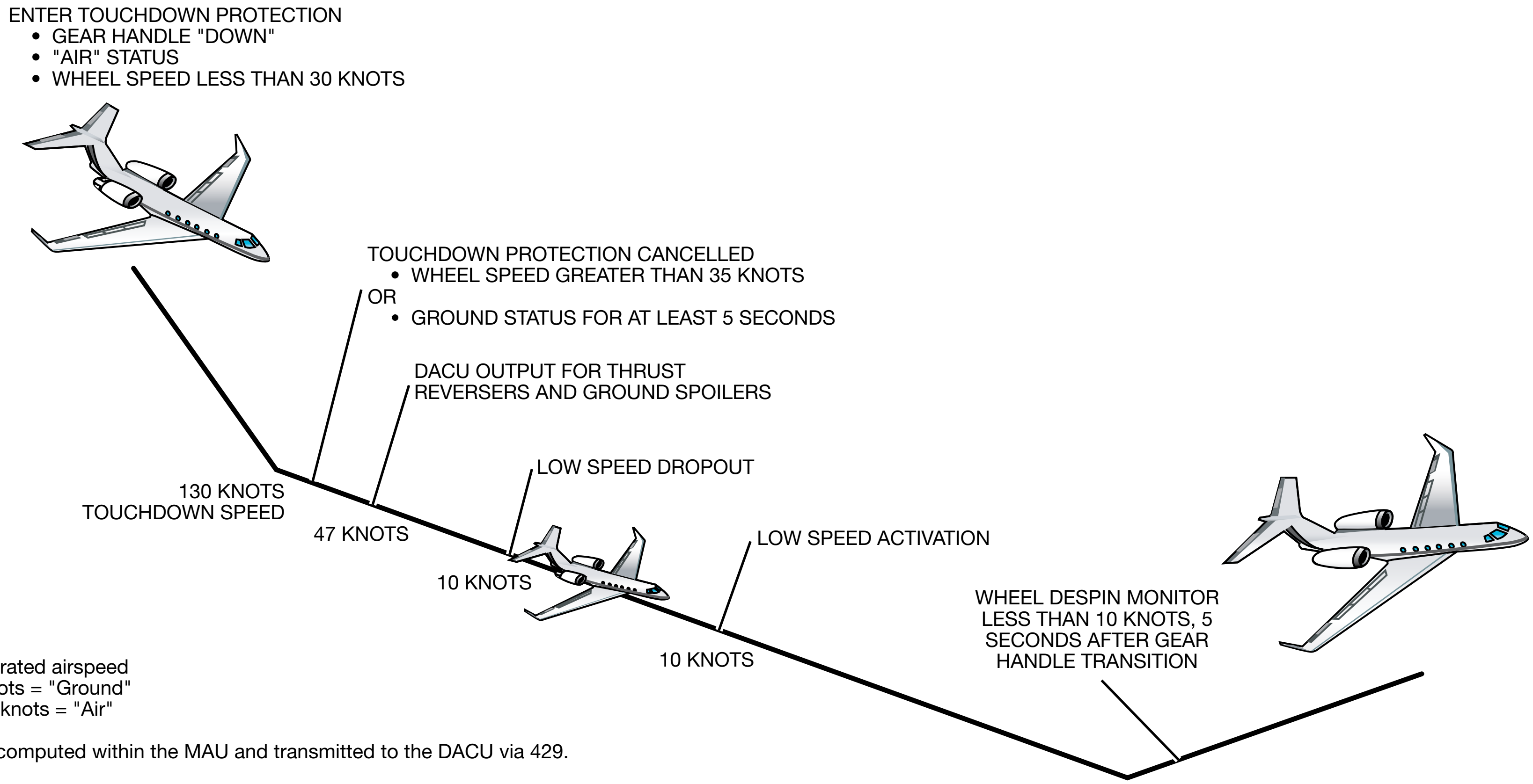
Brake CAS Messages

The crew alerting system provides warnings and cautions of brake system failures (Figure 32-57 and Table 32-1):

- If the anti-skid system has circuit problems, the **Antiskid Fail** message will be displayed.
- If the DACU detects a wheel miscompare for greater than 5 seconds, the **Brake Maintenance Reqd** message will be displayed.
- If either 28V dc power supply or the Weight-On-Wheels (WOW) switches have a miscompare, the **Antiskid Fail** message will be displayed. For this failure, two wheels may be without anti-skid, but the pilot will still have pedal brake control.
- If a brake unit exceeds 650° F **Brake Overheat** indicates on CAS.
- With Anti-Skid selected off, **Anti-skid off** indicates on CAS.

Table 32-1. ANTI-SKID CAS MESSAGES

MESSAGE	DESCRIPTION
Antiskid Off	The antiskid cockpit switch is in the "OFF" position.
Antiskid Fail	Failed wheel speed transducer, failed control valve, wheel not turning, critical DACU failure.
Wheelspeed Monitor	A wheel speed of greater than 47 knots is identified while the system is in the "AIR" mode.
Touchdown Protect Unavail	DACU WOW input indicates ground and gear handle indicates gear "UP".
Wheel Despin Fail	Wheel speed greater than 10 knots, 5 seconds after gear handle positioned "UP".
Brake Overheat	The indicated brake temperature has exceeded 625°C. Removed at 575°C.
Brake Maintenance Reqd	DACU or BTM faults, wheel despin faults, switch disagreements.
Wheelspeed Monitor	One wheel speed sensor is not greater than 47 knots of wheel speed when other wheels indicate > 47 knots.
Parking Brake On	Park/emergency brake pressure switch senses greater than 165 psi of hydraulic pressure.



DACU monitors calibrated airspeed
- Less than 60 knots = "Ground"
- Greater than 60 knots = "Air"

Air/Ground status is computed within the MAU and transmitted to the DACU via 429.

Both cards, independent of the MAUs will verify aircraft Air/Ground status.

DACU - Power up BIT, and continuous monitoring BIT

Basic Anti-Skid and Locked Wheel Protection, available between the system exiting the Touchdown Hydroplane protection and the 10 knot low speed dropout.

Figure 32-58. ABS Anti-Skid Operational Chart

BRAKE SYSTEM OPERATIONS

Touchdown Protection

The touchdown protection feature of the anti-skid system acts to prevent any pressure at the brakes prior to wheel spin up at touchdown. This function of the DACU is activated when the aircraft is in the air mode, the landing gear handle is in the down position and the wheel speed is less than 30 knots.

Wheel speeds of greater than 35 knots, or ground mode for at least 5 seconds, will cancel the touchdown protection. Air or ground mode is validated by the DACU. The DACU uses CAS displayed or calibrated air speed, to override the air or ground mode. Less than 60 knots the DACU will correct to the ground mode.

Air or ground status is computed within the MAU and transmitted to the DACU. The DACU also receives discrete signals from the left and right main gear WOW switches. The DACU will always default to the ground mode whenever their is a disagreement between signals.

Locked Wheel Protection

The locked wheel protection is determined by the DACU based on a 30% difference in wheel speed. The DACU compares observed wheel speed with referenced wheel speed. Locked wheel protection is active above 35 knots.

Anti-Skid Protection

Individual wheel anti-skid protection is monitored and controlled by the DACU referencing wheel speed for control. An algorithm is used to determine maximum wheel deceleration rates for the tire. If the wheel speed transducers exceed this algorithm a skid is assumed and the DSCV are commanded to release the brake pressure (Figure 32-58).

Controlled Wheel Spin Down

The ABS DACU takes an active roll in wheel despin The DACU modulates brake pressure through the dual-skid control valves following the gear handle movement to the up position. An algorithm is used to control the spin down current provided to the dual-skid control valves. The **Wheel Despin Fail** message will be displayed if the wheel speed is greater than 10 knots 5 seconds after landing gear handle transitions to the up position. When the gear is retracted and the anti-skid system is selected “OFF”, the wheel spin down will be performed passively and a thump will be heard by the passengers or crew.

Built in Test

The DACU performs a bit test on start up and continuously as long as power is applied to the system. The power up BIT begins after all wheel speeds are validated that the aircraft is not in motion.

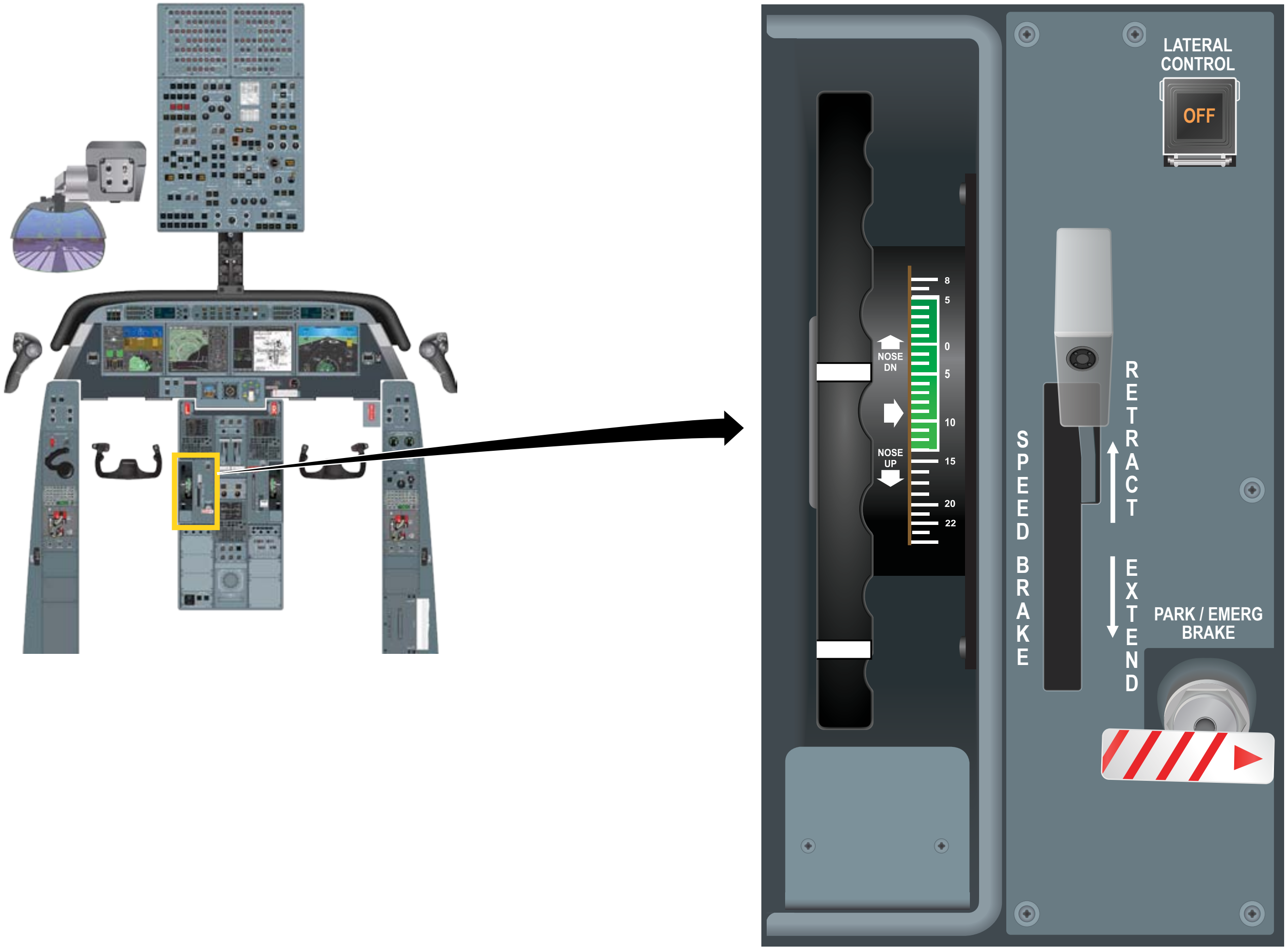


Figure 32-59. Park / Emergency Brake Control Handle

PARK / EMERGENCY BRAKE SYSTEM

PARK/EMERGENCY BRAKE GENERAL

In the event of left or auxiliary system fluid loss the brakes can still be operated by the brake accumulator system (PARK/EMER) brake pressure. Accumulator system pressure is intended to maintain pressure on brakes for extended periods of time without use of toe brakes. If necessary, accumulator system pressure (PARK/EMER brakes) can also be used to stop the aircraft in emergency situations. Anti-skid protection is not available while using the parking brake system.

PARK/EMERGENCY BRAKE COMPONENTS

Park / Emergency Brake Control Handle

Purpose

The purpose of the parking brake control handle is to mechanically manipulate the parking brake control valve.

Location

The parking brake control handle is located on the left aft side of the center pedestal (Figure 32-59).

The parking brake control handle is used to set the aircraft brakes in the parked position. The handle is white with red stripes and is placarded PARK / EMER BRAKE. The brakes are set by pulling the handle up and turning 1/4 turn to the right so that it remains in the pulled position.

The parking brake valve allows metering of the pressure for the first 1/2 inch of travel; further travel will cause full brake pressure application.

Operation

By selecting the PARK / EMER brake handle to the full "ON" position, it applies full accumulator pressure to the brakes. The PARK/EMER selector valve is opened by direct mechanical linkage allowing hydraulic pressure to be applied through a pair of brake fuses, located in the respective main landing gear wheel well, for each strut. The single pressure line is split into two lines at the base of each landing gear strut and into a shuttle valve located at the base of each brake. The shuttle valve opens to allow the emergency system to apply the brakes. When the parking brake handle is released the pressure is released and brakes are released.

With the accumulator fully charged the PARK/EMER handle can be cycled at least six times. Available pressure will reduce with each cycle until the accumulator fluid charge is depleted.

The parking brake system consist of the following components:

- Park / emergency brake control handle
- Park / emergency brake accumulator
- Park / emergency brake control valve

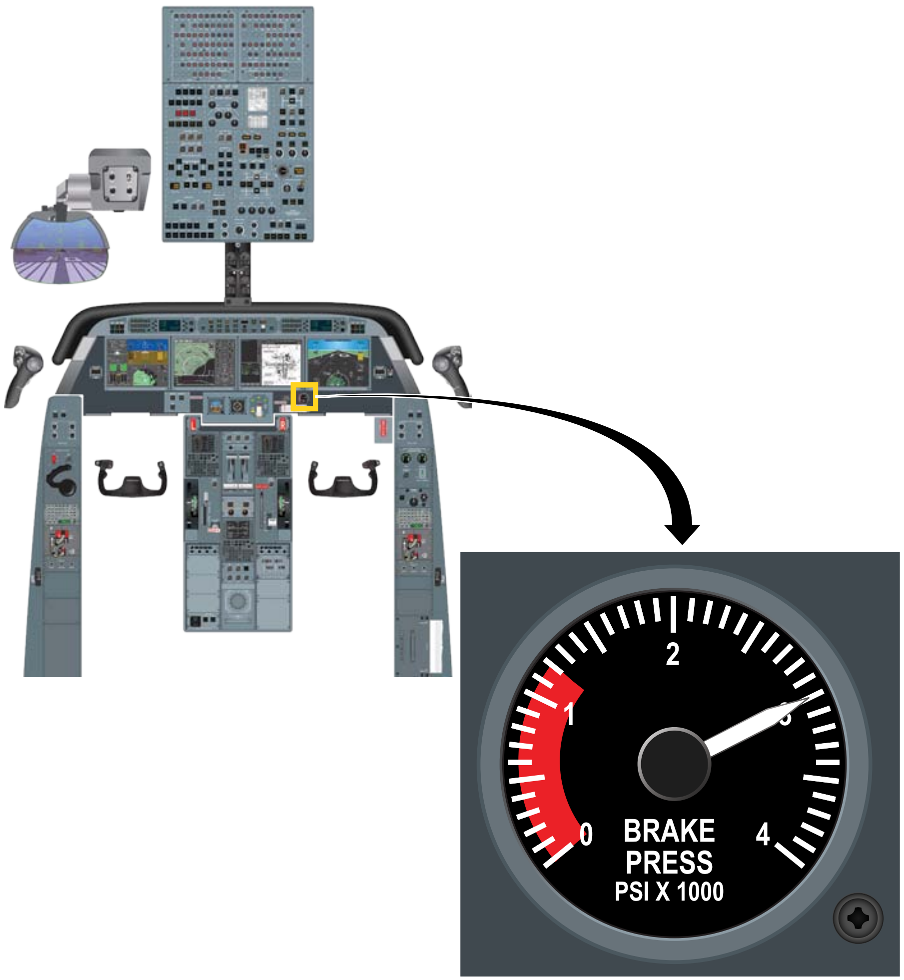


Figure 32-60. Park / Emergency Brake Pressure Gage

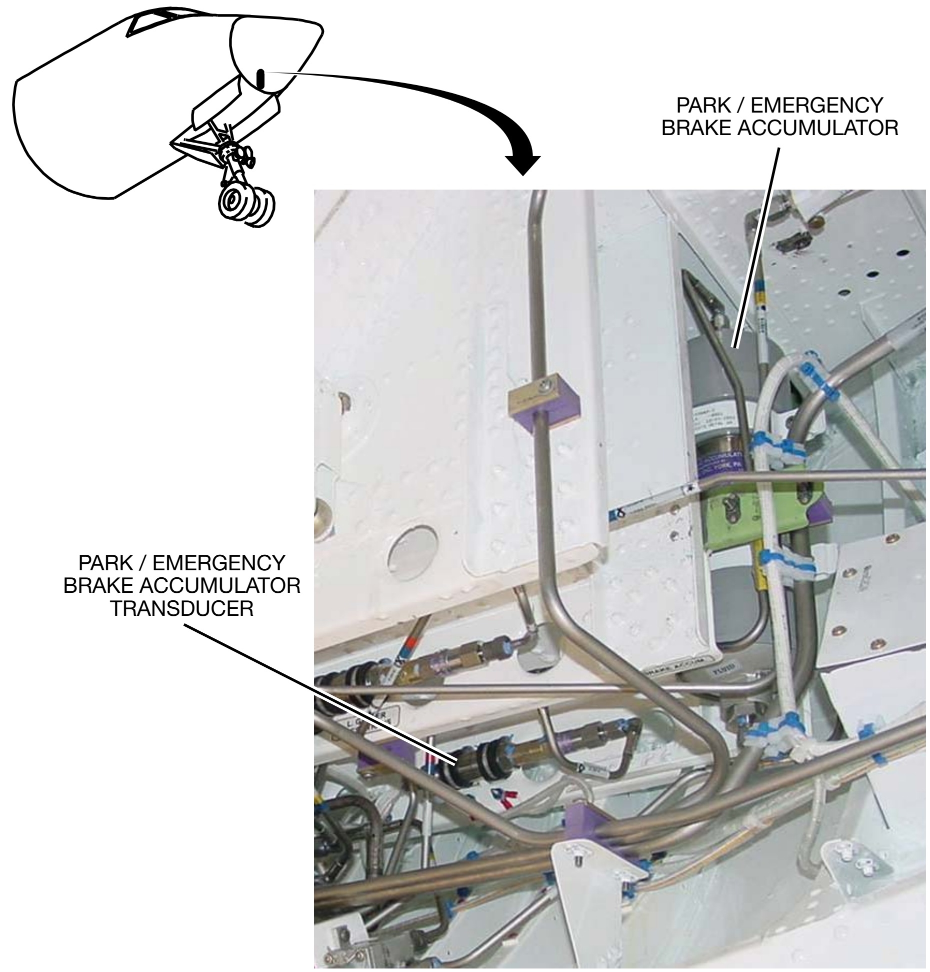


Figure 32-61. Park / Emergency Brake Accumulator and Transducer

Park / Emergency Brake Accumulator

Description

The brake accumulator is a floating piston-type accumulator with a total capacity of 50 cubic inches. The accumulator is charged with nitrogen to a pressure of 1200 psi at 70°F.

A manually operated brake accumulator unloader valve, located in the nose wheel well, can be used to discharge the brake accumulator from the nose wheel well. This is a rotary shutoff valve which is spring-loaded to the closed position.

When the parking brake accumulator is charged with the auxiliary pump, a pressure drop of 200 to 300 psi may occur due to a pressure loss through the check valve as it closes. By turning the aux pump on and off a second time, pressure indications will read closer to 3000 psi.

Park / Emergency brake accumulator pressure is displayed on:

- Copilots skirt panel dial gauge
- Brake synoptic page
- Hydraulic synoptic page
- Summary synoptic page
- Nose wheel well parking brake accumulator gauge.

Purpose

The parking brake accumulator is designed to store nitrogen and hydraulic pressure to be used in the park / emergency brake system (Figure 32-61).

Location

The parking brake brake accumulator is located in the upper left side of the nose wheel well area (Figure 32-60).

NOTES

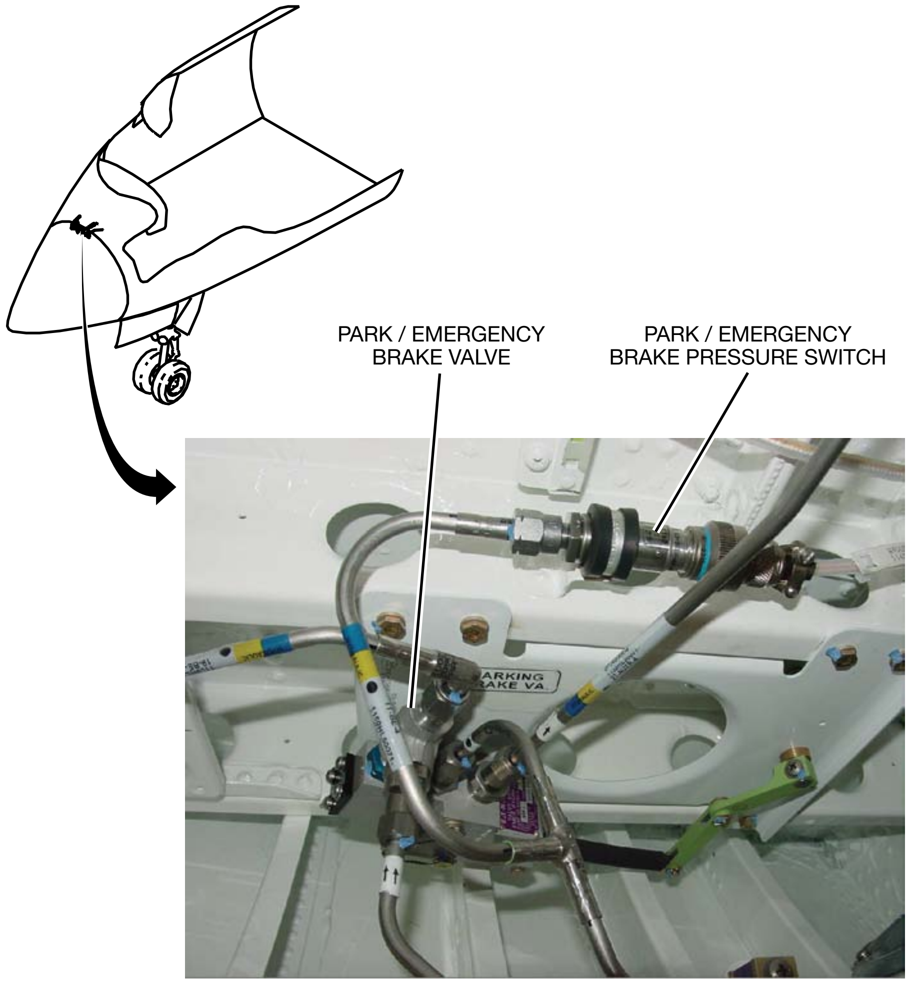


Figure 32-62. Park / Emergency Brake Valve and Pressure Switch

Control Valve

Description

The park / emergency brake control valve is controlled by the parking brake handle in the cockpit. The valve ports pressurize hydraulic fluid to the park / emergency brake system. The valve is capable of pressure modulation because of an internal diaphragm. The modulating function of the valve can be damaged if the pressure on the inlet port is relieved (via the unloader valve) while the valve is maintaining pressure on the system (Figure 32-61). If the valves internal diaphragm is damaged the flight crew will not be able to modulate the valve during emergency operation of the parking brakes. There is no external indication when the diaphragm in the valve is damaged.

Fluid pressure that originates from the park / emergency brake valve passes through a single hydraulic line until the fluid line is divided into left and right emergency brake lines forward of the main landing gear wheel wells. A brake fuse in each park/emergency brake line is located outboard of each main gear door control valve. The brake fuse must be opened to bleed the emergency brake system hydraulic lines which attach to the front of the brake shuttle valves located on the bottom of the brake assemblies.

Purpose

The purpose of the park / emergency brake control valve is to transfer, modulate and maintain hydraulic pressure on the brake system.

Location

The park / emergency brake control valve is located on the right side of the nose wheel well (Figure 32-62).

Pressure Switch

Purpose

A pressure switch is included in the parking brake control pressure line to indicate to the crew when parking brake pressure is applied to the system. The pressure is also monitored by MAU 1 to control activation of the Keep Out Zone (KOZ) function when operating engines on the ground.

Location

The park / emergency Pressure Switch is located on the right side of the nose wheel well (Figure 32-62).

NOTES

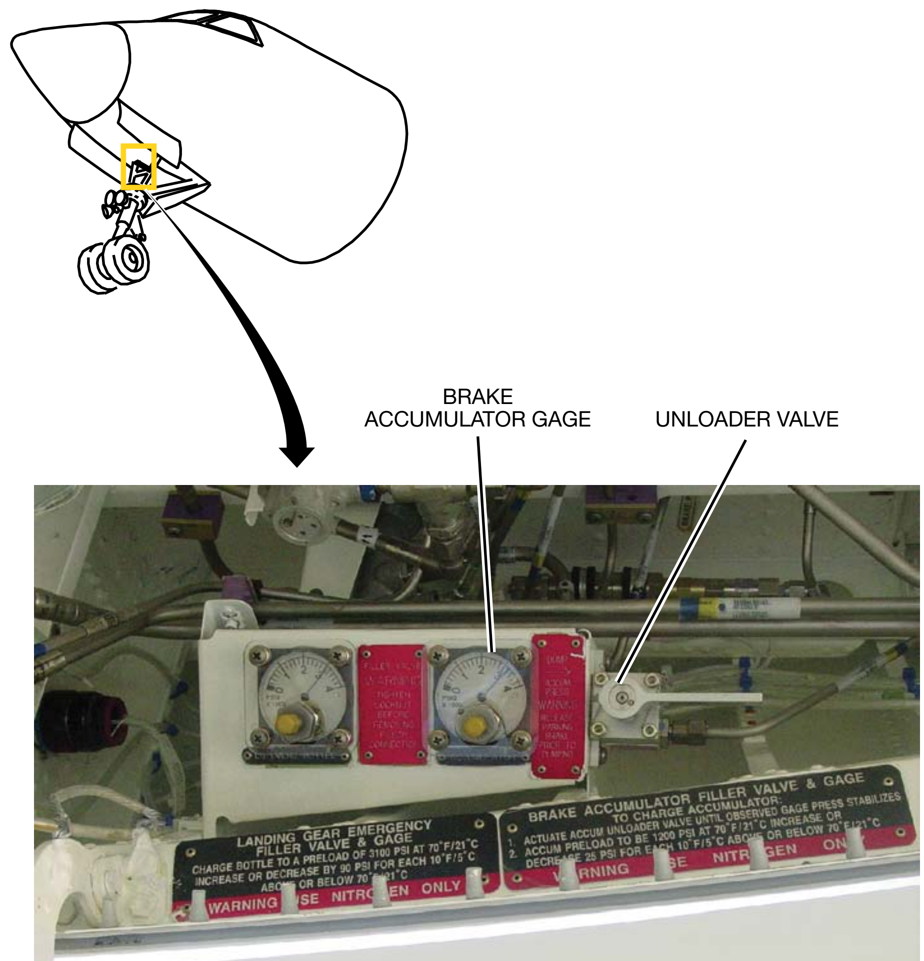


Figure 32-63. Accumulator Gage and Unloader Valve

Nitrogen Servicing Panel

Purpose

The purpose of the nitrogen servicing panel is to replenish the emergency brake system accumulator. It also houses the unloader valve which is used to relieve hydraulic pressure on the accumulator.

Location

The Nitrogen Servicing Panel is in the nose wheel well left hand side (Figure 32-63)

CAUTION

Before unloading the accumulator from the nose wheel well position by using the brake accumulator unloader valve, ensure that the aircraft is chocked since the brakes will release when the accumulator is unloaded.

Unloading the accumulator by using the brake accumulator unloader valve with the park / emergency brake applied could cause damage to the metering park / emergency brake valve, if brakes are not released prior to operating the unloader valve.

NOTES

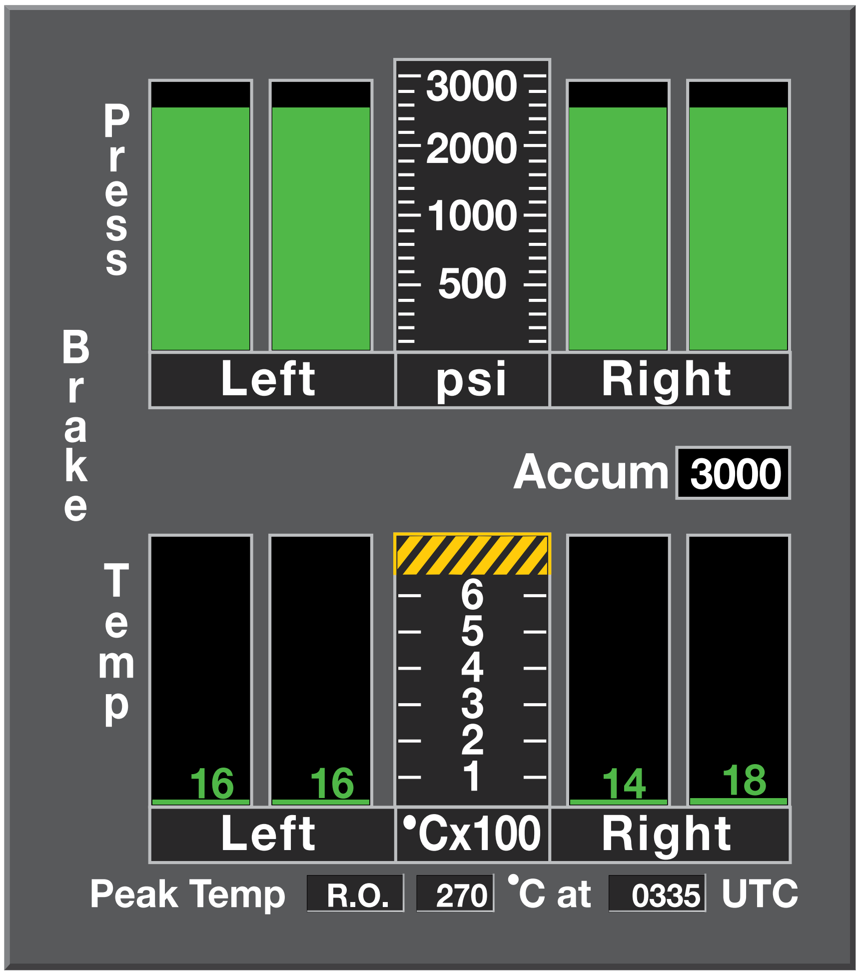


Figure 32-64. Brake Synoptic Page

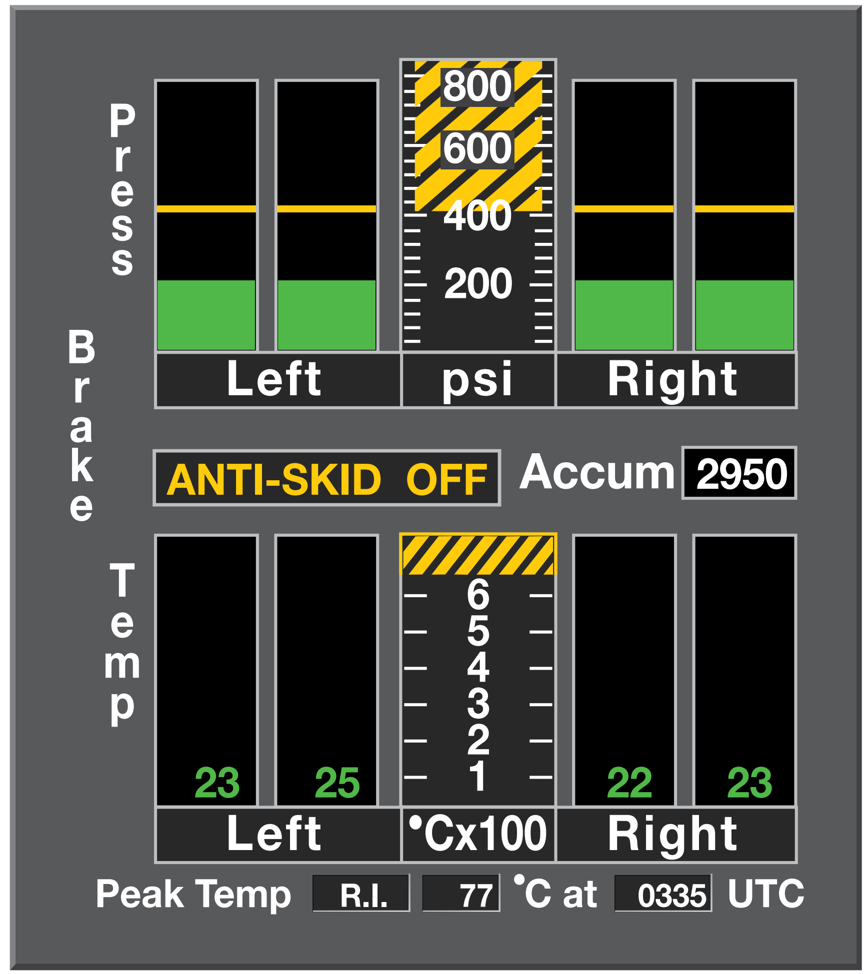


Figure 32-65. Brake Synoptic Page—Anti-Skid Off

PARK/EMERGENCY BRAKE INDICATIONS

Brake System Synoptic Page

The brake synoptic page displays wheel brake pressure and temperature as graphs with individual vertical bars (Figure 32-64). The top portion of the synoptic page displays the four bars for pressure and the bottom portion four bars for temperature. Park/Emergency brake accumulator pressure is shown between the temperature and pressure graphs. Last gear cycle, highest peak brake temperature is shown at the bottom of the page.

If the flight crew were to select the anti-skid system to off via the ON/OFF switch located in the flightdeck center console, the brake synoptic display will change (Figure 32-65). The psi scale in the middle will convert from a 0 to 3000 scale to 0 to 800 psi scale. The message "ANTI-SKID OFF" message will be displayed in the center of the page. The four pressure bar graphs at the top of the page will have a yellow reference line across the 400 psi graduation, and everything above 400 psi will have yellow caution bars across the scale.

Four individual pressure transducers transmit brake pressure for each brake assembly. The transducers are located down stream of the dual-skid control valves.

Park / emergency brake pressure indication is provided through a shuttle valve on each side of the aircraft. This valve allows pressure to shuttle to one of the normal system pressure transducers on each side, the MAU duplicates the pressure indication, for display on the synoptic page.

NOTES

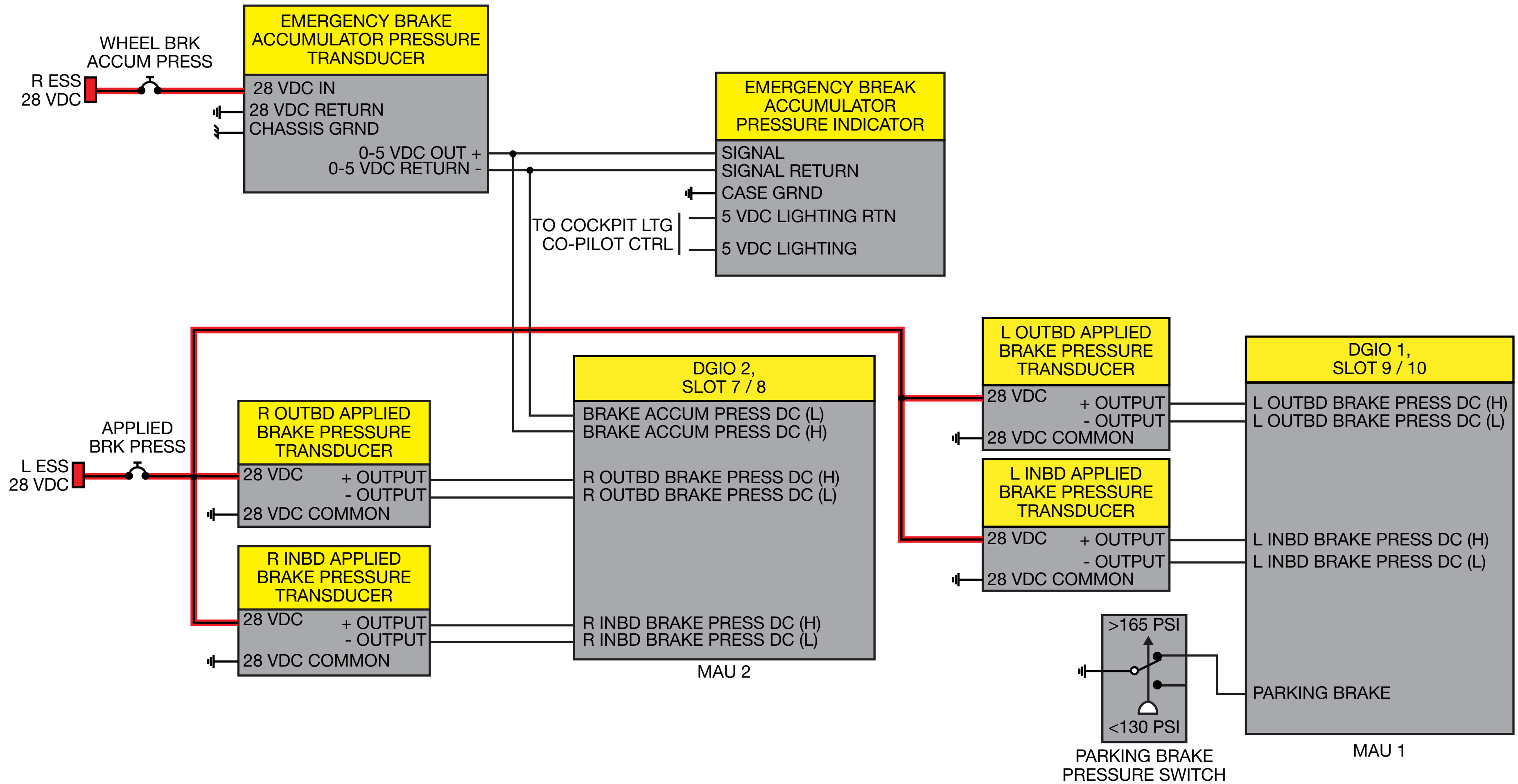


Figure 32-66. Brake Pressure Indication

Brake System Pressure Indication

The left inboard and outboard transducers send their data to DGIO 1, Slot 9/10 in MAU 1

The right inboard and outboard pressure transducers send the pressure signal to MAU 2 DGIO 2, Slot 7/8 as does the emergency / parking brake accumulator pressure transducer. These indications end up on the Brake system synoptic page and the accumulator indication is also seen on the Hydraulic and Summary page.

MAU 1 also recieves the parking brake on signal which generates the blue **Parking Brake On** CAS message enabeling the EEC to auto protect the engine from the Keep Out Zone (KOZ) (Figure 32-66).

NOTES

NOTES

Carbon Brake Disk Contamination

Aircraft high-pressure hydraulic brake assemblies are designed to absorb tremendous amounts of kinetic energy and then dissipate the energy as heat. Steel brake assemblies were the first choice of aircraft designers due to the low cost of acquisition and maintenance. Non-metallic, or carbon brake elements are used in applications where the lighter weight of the brake assembly is a primary need. The carbon brake assembly is also capable of absorbing more energy in relation to the brake mass as compared to steel brakes. However, carbon brake elements are usually very expensive (4 to 8 times the cost of metallic) for a lifetime (initial cost, refurbish/overhaul costs, etc) and are maintenance critical. The carbon disks are susceptible to contamination and great care should be taken to avoid accidental contamination.

NOTES

Carbon will naturally absorb organic solvents like:

- Aromatic hydrocarbons (benzene, toluene, xylene)
- Isopropyl alcohol
- Methanol
- Chlorinated Hydrocarbons (ethylene dichloride, methylene chloride, perchloroethylene, trichloroethylene, trichloroethane)
- Naphthas
- Petroleum solvents (kerosene, gasoline, mineral spirits)
- Turpentine
- Acetone
- Hydraulic fluids

NOTE

Water, the most common solvent, is an “inorganic” solvent because it does not contain carbon.

Once aircraft brakes have become contaminated they may expand and cause dragging brakes or reduced effectiveness. The most hazardous effect to contaminated brakes is their susceptibility to ignite causing an aircraft fire, once brake temperatures reach the flash point of the organic solvent.

Cleaning Carbon Disk Brakes

Care should be taken to avoid contamination of the carbon brake assemblies. For general cleaning, use a soft bristle brush and a vacuum cleaner. If liquid contaminant's such as hydraulic fluids, grease or solvents come in contact with the carbon disks, they should be flushed from the assembles with distilled water, or wipe the disks with an alcohol soaked absorbent cloth. If the carbon disks are saturated the brake assembly must be removed. Hydraulic fluids are considered a low risk contaminant, however aircraft deicing fluids, especially runway deicing fluids are a high risk contaminant that increases oxidation of the carbon 2 times or greater.

NOTES

Procedures for Hot Brakes

Aircraft brake temperatures can exceed 625°C. If temperatures rise or remain above the overheat limit for more than 5 minutes, the aircraft should be evacuated. All personnel should remain clear of the main landing gear for a minimum of 30 minutes to allow the brakes and tires to cool. The nose tires should be chocked and the parking brake released. Large fans can be utilized to cool the brake assemblies. Water should never be used to cool hot aluminum wheels and brakes. The rapid cooling may cause structural failure of the metal wheel assembly causing an explosive depressurization of the wheel and tire.

NOTES

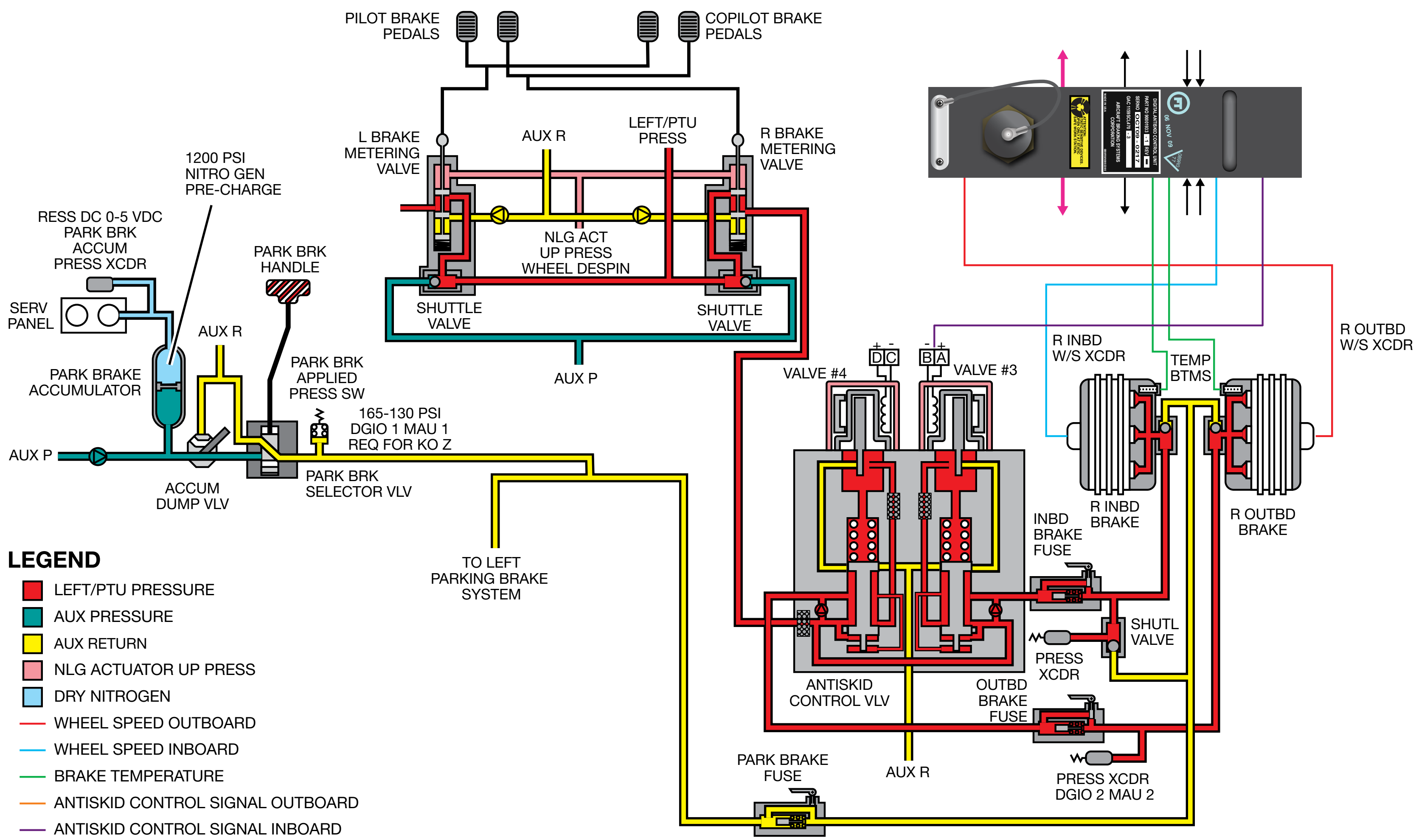


Figure 32-67. Brake Operation Schematic

PARK/EMERGENCY BRAKE OPERATION

The brake pedals are are operated by the pilot or copilot. Pressing on the tops of the rudder pedals causes the pedals to rotate forward which actuates a mechanical linkage. The linkage allows for independent operation of the left or right toe brake. Below the floor of the cockpit, two torque tubes combine the inputs to operate the two brake metering valves control valves which extend into the lower sub floor of the cockpit. Brake pedal switches located only on the pilots brake pedal linkage indicate brake pedal movement (Figure 32-67). The switches are utilized when the auxiliary hydraulic pump system logic is in the "ARMED" mode. Any brake pedal movement with the system armed and no hydraulic pressure available to the left system or PTU, activates the auxiliary hydraulic pump allowing brake pressure to be applied.

The brake system is a mechanically operated, hydraulically powered, brake control system. The brake system features independent control of all main wheels in normal operation, and allows independent pilot controlled emergency braking. The Pilot initiates braking commands mechanically through the toe brakes on top of the rudder pedals or via the emergency / parking brake handle. A Brake Temperature Monitor System (BTMS) measures brake stack temperatures. Both brake pressure and temperature are displayed to the crew via the brake synoptic page.

During normal operation, the pilot sets the level of desired braking through toe pedal displacement. Left and right Brake Metering Valves (BMV) convert pedal displacements into hydraulic commands. Pressure for brake application is obtained from the 3000 psi left hydraulic system. In the event of a left hydraulic system failure, the PTU or auxiliary hydraulic system pressure is utilized through the same fluid lines and components. The AUX hydraulic system fluid is separated normally through the use of check valves. Two Dual Skid Control Valves (DSCV) modify the pressure as delivered to each carbon brake. A single input to each DSCV is divided into an inboard brake and outboard brake pressure. A Digital Anti-Skid Control Unit (DACU) monitors each wheel's speed and activates individual channels of the DSCV, modifying brake pressure as needed to preclude deep skidding.

During emergency operation, the pilot selects the level of desired braking through emergency / parking brake handle displacement. A modulation valve converts handle displacement into a single hydraulic command. This single commanded hydraulic pressure is delivered uniformly to the carbon brakes.

NOTES

Figure 32-68. Nose and Landing Gear

AIRCRAFT JACKING AND TIRE REMOVAL

When jacking the aircraft, release the parking brake to allow the aircraft to roll while jacking and de-jacking. Failure to release the parking brake and allow free rotation of the wheels may cause the aircraft to jump off the jack pad (Figure 32-68).

Prior to removing the aircraft wheel assembly, the parking brake must be set to maintain brake rotor alignment. This will facilitate the installation of the wheel drive keys onto the brake assembly. Once the wheel has been reinstalled, the parking brake should be released to lower the aircraft off the jacks.

NITROGEN SERVICING

Servicing of aircraft tires should be accomplished with low pressure nitrogen. Extreme damage to personnel and the aircraft could occur if the tire is serviced with more than the recommended tire pressure. If a rupture were to occur the tire and steel cable in the tire bead will more than likely remain in tact while the aluminum rim and bolts will fail first. It is recommended that a stand-off nitrogen filler gauge be used for servicing, and the proper safety procedures for use of nitrogen bottles or servicing carts should be followed.

NOTES

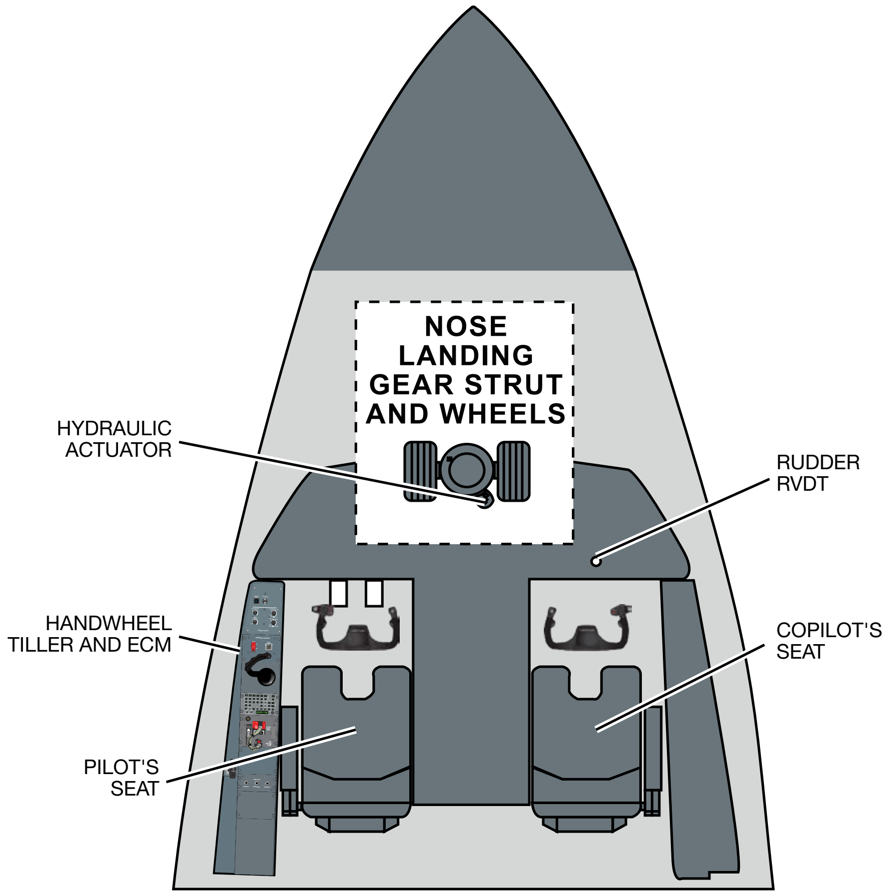


Figure 32-69. Nosewheel Steering Layout

NOSEWHEEL STEERING SYSTEM

NWS INTRODUCTION

This chapter presents an basic overview of the G450 Nose Wheel Steering (NWS) system which is utilized for taxi, takeoff and landing. The material contained in this course is based on approved maintenance manual procedures, and engineering documents. Employees are reminded to utilize current technical data to perform any procedure on any Gulfstream aircraft (Figure 32-69).

NWS DESCRIPTION

The Nose Wheel Steering (NWS) is an electronically signaled, hydromechanical, servo controlled, power steering system. Hydraulic pressure is supplied from the left system or PTU (see *MSM* Figure 29-69).

Mechanical commands from the pilot through the hand wheel (tiller/ECM) and/or the rudder pedals are converted to electrical signals by Rotary Variable Differential Transformers (RVDT). These signals are processed through an Electronic Control Module (ECM) which then commands the Electro-Hydraulic Servo-Valve (EHV) on the hydromechanical power unit providing fluid control of the motor, which provides the driving force to turn the gearbox and nose wheels.

The nose wheels can be turned 80° ± 1.6°either side of straight ahead by handwheel tiller movement. The rudder pedals can command the nose wheel steering 7°/±1°right or left. A tiller failure increases rudder pedal steering authority to 16°left or right. Maximum nose wheel deflection is 82° either side of straight ahead even when the tiller and rudder pedal inputs are combined. The minimum taxi strip for a 180° turn is 60 feet at 80° of nose wheel deflection. If the ECM detects a failure other than the RVDTs, it will shut down active steering and steering will have to be accomplished through differential braking.

The nose wheel steering electronic control module includes variable gain of operation based on aircraft ground speed. Degrading of the tiller output will begin when the aircraft ground speed, based on IRS input to the NWS ECM, is at or above 12 knots.

The G450 nose wheel steering can be supplied with 3000 psi of hydraulic pressure from either the:

- Left
- PTU

Figure 32-70. Handwheel Tiller and ECM

NWS COMPONENTS

This chapter will cover the purpose location and operation of the major components that make up the nose wheel steering to include:

- Hand wheel tiller / ECM (Figure 32-69) and control panel
- Pedal steering controls
- Nose wheel steering hydraulic actuator
- Electronic control module assembly

Electronic Control Module Assembly

The ECM is powered by aircraft R essential 28VDC bus through a circuit breaker in the Right Electronics Equipment Rack (REER) circuit breaker panel labeled “STEER BY WIRE” 5 AMP. Power is available to a steer by wire control relay and the nose gear WOW switch. The relay controls the only power source to the ECM. The nose gear WOW switch circuit ensures the aircraft is on the ground before the ECM can hydraulically control the NWS (Figure 32-70).

The PWR STEER ON/OFF switch activates the ECM circuitry and sends power to the No. 1 solenoid valve. The solenoid ports hydraulic fluid to the EHSV so that the ECM can performs a control and feedback check on the EHSV. Once the nose gear is placed in the ground mode or WOW, the system receives power through the nose WOW circuit. The ECM logic then energizes the No. 2 solenoid valve providing pressurized hydraulic fluid to the NWS motor. The ECM performs continuous BIT monitoring to search for failures. The ECM removes power, if necessary. Failures are displayed on CAS and stored in the Central Maintenance Computer (CMC) for ground crew maintenance.

Inertial Reference System inputs ground speed to a processor within the tiller / ECM. The processor modulates the available voltage to the EHSV reducing the servo valves maximum command capability.

The ECM sets bits on the ARINC 429 output data bus to SGIO 1 on MAU No. 1 and SGIO 4 on MAU No. 2 . The tiller / ECM uses a single output which is split between the MAUs.

The discrete output for “Nose Wheel Steering Off” is an open / 28VDC output to MAU No. 1 and No. 2. If the MAUs don’t acquire 28VDC on this discrete one second after the nosewheel is down and locked the blue message **Steer By Wire Off** will be displayed on CAS. CAS will only display these messages if nose wheel is down and locked.

Other functions of the ECM include, fluid warming logic (gear down in air mode), fail safe logic and time delay (fade in).

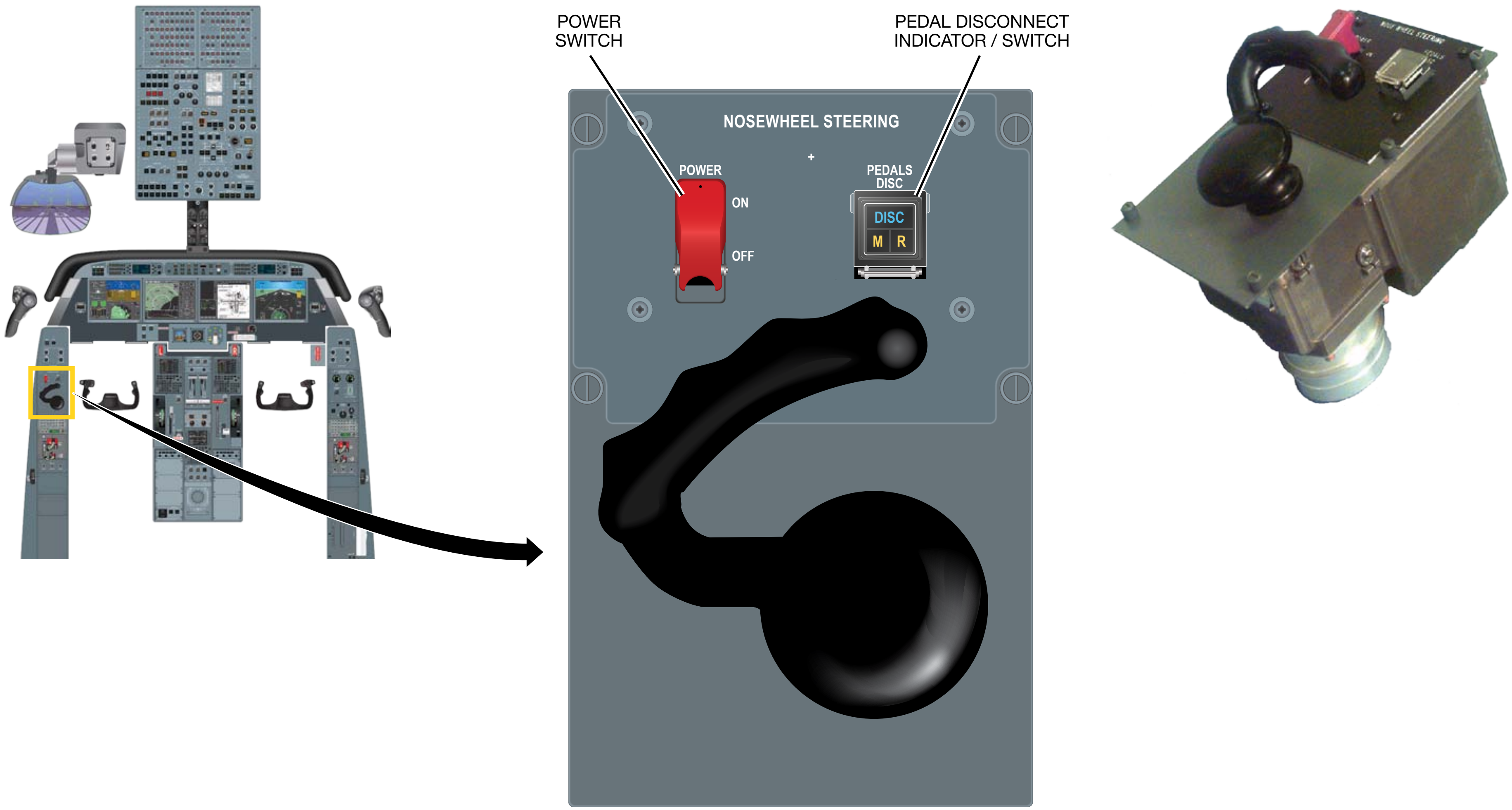


Figure 32-71. Hand Wheel Tiller/Control Panel

Hand Wheel Tiller And Control Panel

Purpose

The hand wheel tiller and Electronic Control Module (ECM) are combined into one assembly and will operate the nose wheels through 80° degrees of authority left and right of center. The electronic control module is designed to take electrical inputs from the hand wheel tiller RVDT, rudder pedal RVDT and the feedback RVDT, compute these signals, and send a command signal out to the EHSV on the NWS hydraulic actuator. The ECM and hand wheel assembly is a line replaceable unit (LRU).

Location

The hand wheel tiller is located on left side of the cockpit on the pilot's side console (Figures 32-71).

The top panel contains three items:

- Handwheel tiller
- Power Switch (guarded ”ON”)
- Pedal disconnect indicator / switch (guarded)

Handwheel Tiller

Handwheel tiller position is centered by a spring. A damper supplies resistance and the handwheel maximum rotation is limited by two stops.

Pedal Disconnect Power Switch

The power switch energizes the electronic control module to operate the nose wheel steering system.

Pedal Disconnect Indicator / Switch Rigging Function

The pedal disconnect switch prevents, movement of the rudder pedals from actuating the nose wheel steering. This option of the nose wheel steering was originally implemented on the GIV aircraft to prevent a AOG due to a failed pedal RVDT. With this option the rudder pedal RVDT signal is eliminated from the normal operation of the system and the aircraft can be dispatched.

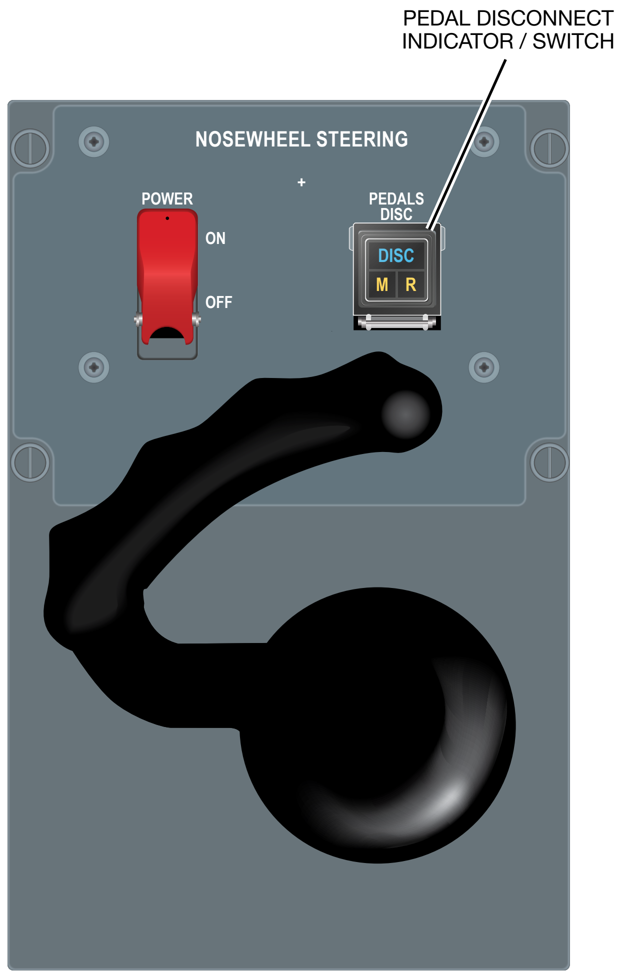


Figure 32-72. Pedal Disconnect Indicator Switch

Pedal Disconnect Indicator / Switch Rigging Function

The PEDALS DISC switch contains three internal lights:

- DISC—Blue in color. Indicates rudder pedal steering capability is off.
- M (Maintenance)—Amber in color. Indicates the NWS is in the maintenance mode.
- R (Rig)—Amber in color. Indicates the NWS is in the rigging mode when flashing.

The nose wheel steering ECM is capable of an electrical autorig function. The pedal disconnect switch is utilized to activate the autorig function.

When initiating the electrical autorig function of the nose wheel steering system verify that the mechanical system is centered or nulled by following the maintenance manual procedures before attempting an electrical autorig.

To activate the autorig function, press the PEDALS DISC switch (Figure 32-72) ON and back OFF, four times in a four to ten second period. The "M" and the "R" lights will be used to determine if additional adjustments are necessary or if the tiller / ECU or Actuator needs to be replaced. The "R" will flash verifying that the rudder pedal RVDT is within 2 degrees of its electrical nulled position. If the "R" does not flash after initiating the autorig function. The rudder pedal RVDT must be adjusted to within ±2° of its electrical null position. Following adjustments the "R" should flash, indicating the autorig process can continue. To continue the electrical rigging process the PEDALS DISC switch should be pressed ON and back OFF, two more times. A completed autorig will be identified by the illumination of a steady "M and R" in the PEDALS DISC switch (Figure 32-72).

If the "M" flashes, there is a problem with either the tiller RVDT or position RVDT. The rate at which the "M" flashes will determine the item that needs to be adjusted or replaced.

- If the M flashes at a rate of once per second (1Hz), the tiller transducer is out of rig. Possible problem with the tiller / ECM.
- If the M flashes at a rate of 1.5 times per second (1.5Hz), the position feedback is out of rig. Possible problem with the NWS actuator.
- If the M flashes at a rate of 2.5 times per second (2.5Hz), the position feedback and tiller transducer are out of rig. Possible problem with both the NWS actuator and tiller / ECM.

NOTE

If it is difficult to tell the flash rate, rotate and hold the tiller. If the flash rate increases, then the fault is with the position feedback. If the flash rate remains the same, the problem is the tiller.

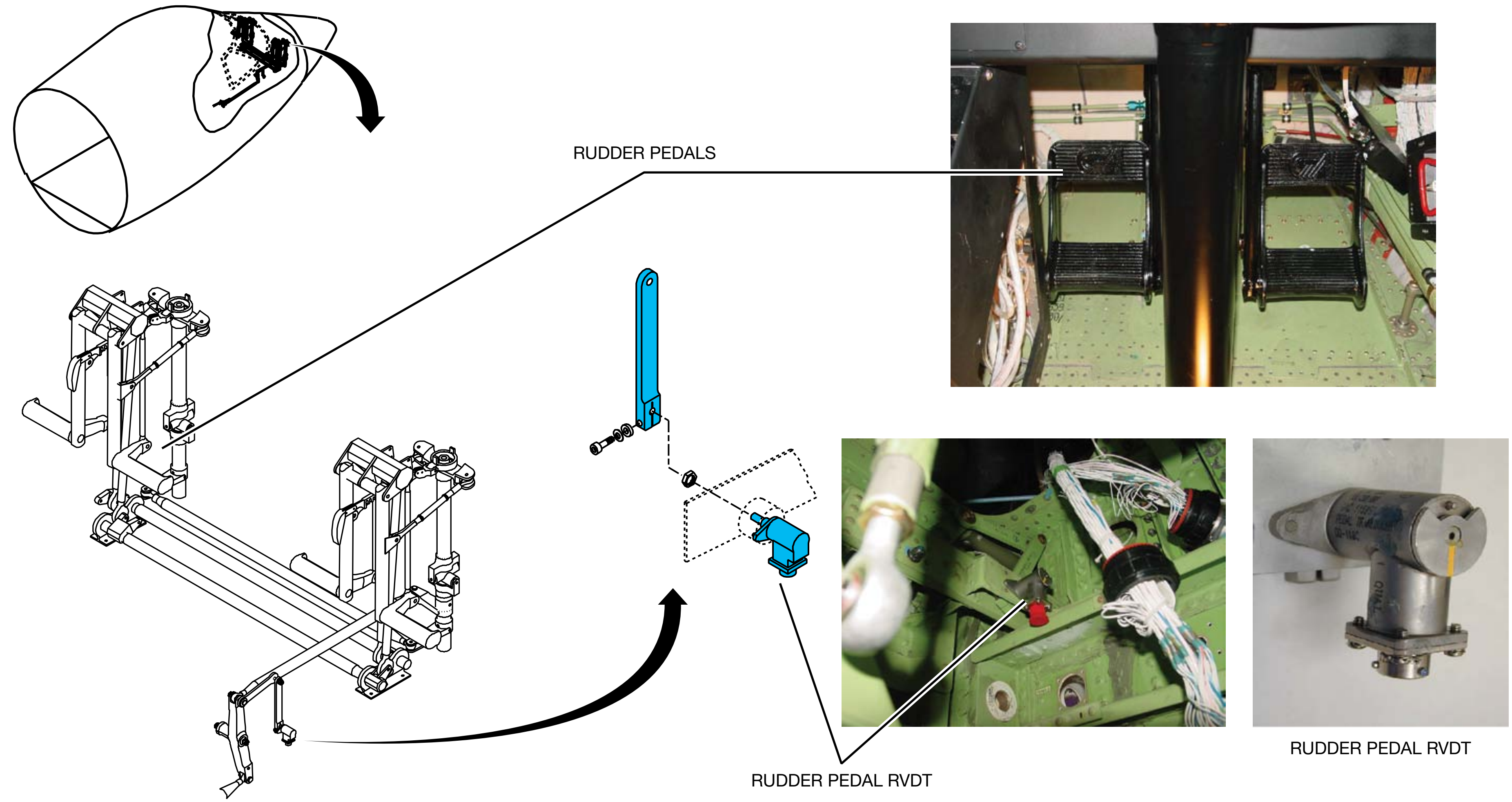


Figure 32-73. Rudder Pedals and RVDT

Rudder Pedal Steering Controls

Purpose

The rudder pedal steering control system allows operation of the nose wheels steering system through 7 degrees of authority left and right of center.

Location

The rudder pedal steering control system includes rudder pedals and a dual rudder RVDT (Figure 32-73). The rudder pedals are located at the pilots and copilots feet and the dual rudder RVDT is mounted on a bracket beneath the right side of the cockpit. The RVDT is mechanically connected to the rudder control torque tube on the right side.

For R/R or adjustment, access to the potentiometer is through the right cheek panel from outside the aircraft or through the co-pilots yoke boot from the cockpit.

Operation

A linkage causes the rotary shaft to rotate as pilot or copilot moves their respective rudder pedals. This in turn sends out a electrical signal to the electronic control module which allows 7 degrees of steering authority left and right of center.

NOTES

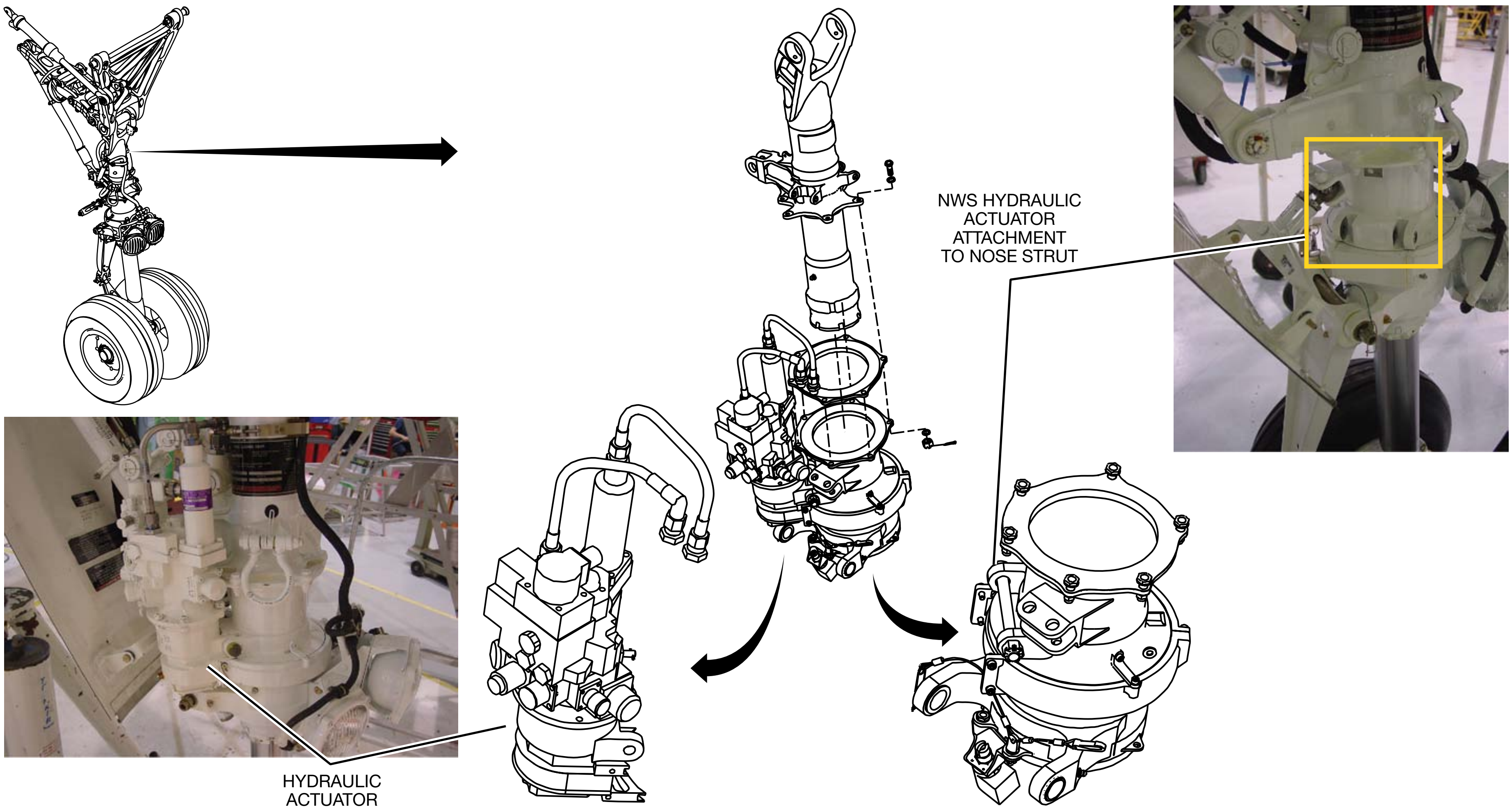


Figure 32-74. NWS Hydraulic Actuator

Nose Wheel Steering Hydraulic Actuator

Purpose

The hydraulic actuator is designed to mechanically move the steering collar which in turn sends mechanical input through the torque links to turn the nose wheels in the desired direction.

Location

The hydraulic actuator is an LRU and is installed on the nose gear strut collar assembly (Figure 32-74).

CAUTION

To prevent damage to steering unit and collar assembly, ensure torque link is disconnected prior to towing aircraft.

Discription

The steering unit, located on the nose gear, is supplied with hydraulic pressure from the left or PTU system. The actuator consists of inline filters, a pressure operated hydraulic shut-off and check valve, two solenoid valves (SOV#1 and SOV#2), Electro-Hydraulic Servo Valve (EHV), a Linear Variable Differential Transformer (LVDT), Bypass/relief valve, compensator, hydraulic motor, gear box, and a position feedback RVDT. The actuator drive gear, at the bottom of the unit, is connected to the drive gear on the nose wheel strut lower collar. The collar rotates around the strut, and the nose wheels will turn due to the interconnect with the torque links. When no hydraulic pressure is applied, check valves hold fluid within the actuator and compensator to aid in shimmy dampening of the nose wheels.

NOTES

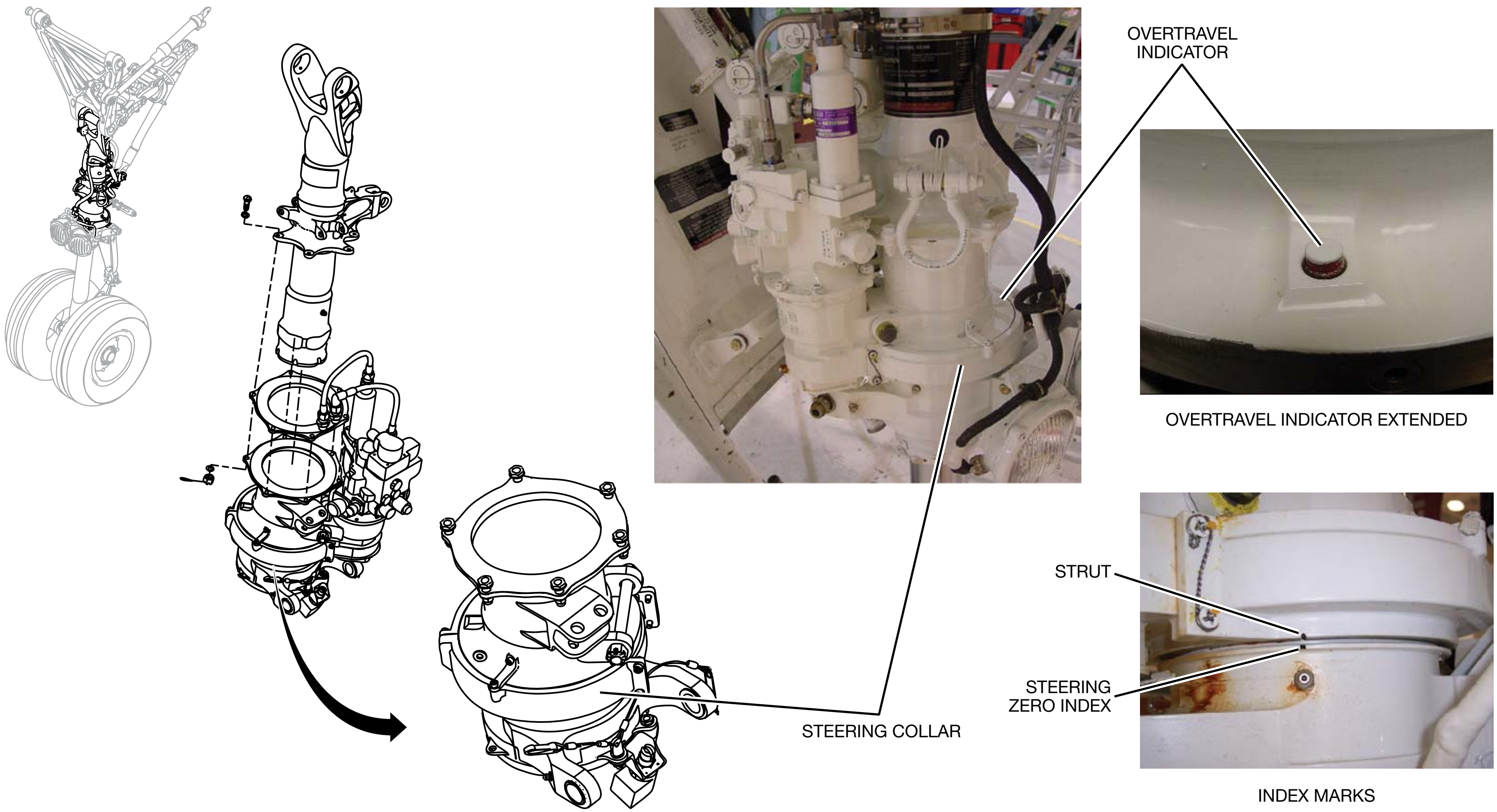


Figure 32-75. Nosewheel Steering Collar

Steering Collar

The steering collar wraps around the nose gear strut and is located on the lower part of the nose gear strut. It includes a collar gear that Accepts inputs from the gearbox pinion gear and a torque link to transfer nose wheel steering inputs to the nose wheels and internal stops (shear pin). If the overtravel indicator has popped up, the steering collar must be inspected. The over-travel indicator must be reset and the shear pin inspected prior to dispatch (Figure 32-75).

The collar contains index marks cut into the metal housing. A single, zero reference index mark on the nose gear strut aligns with the zero reference mark on the steering collar. Two reference marks on the front and back of the steering collar identify 80 and 83 degrees of nose wheel travel.

NOTE

Refer to the *Aircraft Maintenance Manual (AMM)* Chapter 5—"Unscheduled Maintenance" for overtravel indicator reset and inspection procedures.

NOTES

NWS CONTROLS

Steering Tiller

Steering tiller provides 80 degrees ± 1.6°either side of straight ahead by handwheel tiller movement.

RudderPedal Rotary Variable Directional Transducer (RVDT)

Rudder steering control is limited to 7 degrees ±1 left or right of center unless tiller steering failure occurs, then rudder steering authority increases to 16 degrees left or right of center.

NWS INDICATIONS

CAS Messages

There are six messages associated with the nose wheel steering (Table 32-2).

- Steer By Wire Fail
- Rudder Steering Fail
- Tiller Steering Fail
- Rudder Steering Off
- Steer By Wire Off
- NWS Fixed Gain

Table 32-2. NOSE WHEEL STEERING CAS MESSAGES

MESSAGE	DESCRIPTION
Steer By Wire Fail	Electrohydraulic servo valve failure.
Rudder Steering Fail	Rudder Pedal RVDT failure.
Tiller Steering Fail	Tiller steering RVDT failure.
Rudder Steering Off	Pedal disconnect switch is selected.
Steer By Wire Off	Nose wheel steering power switch is not selected ON.
NWS Fixed Gain	Loss of IRS 1 and 2 inputs to nose wheel steering NWS reverts to constant gain at all speeds.

* These messages will only be displayed if the nose landing gear is down and locked.

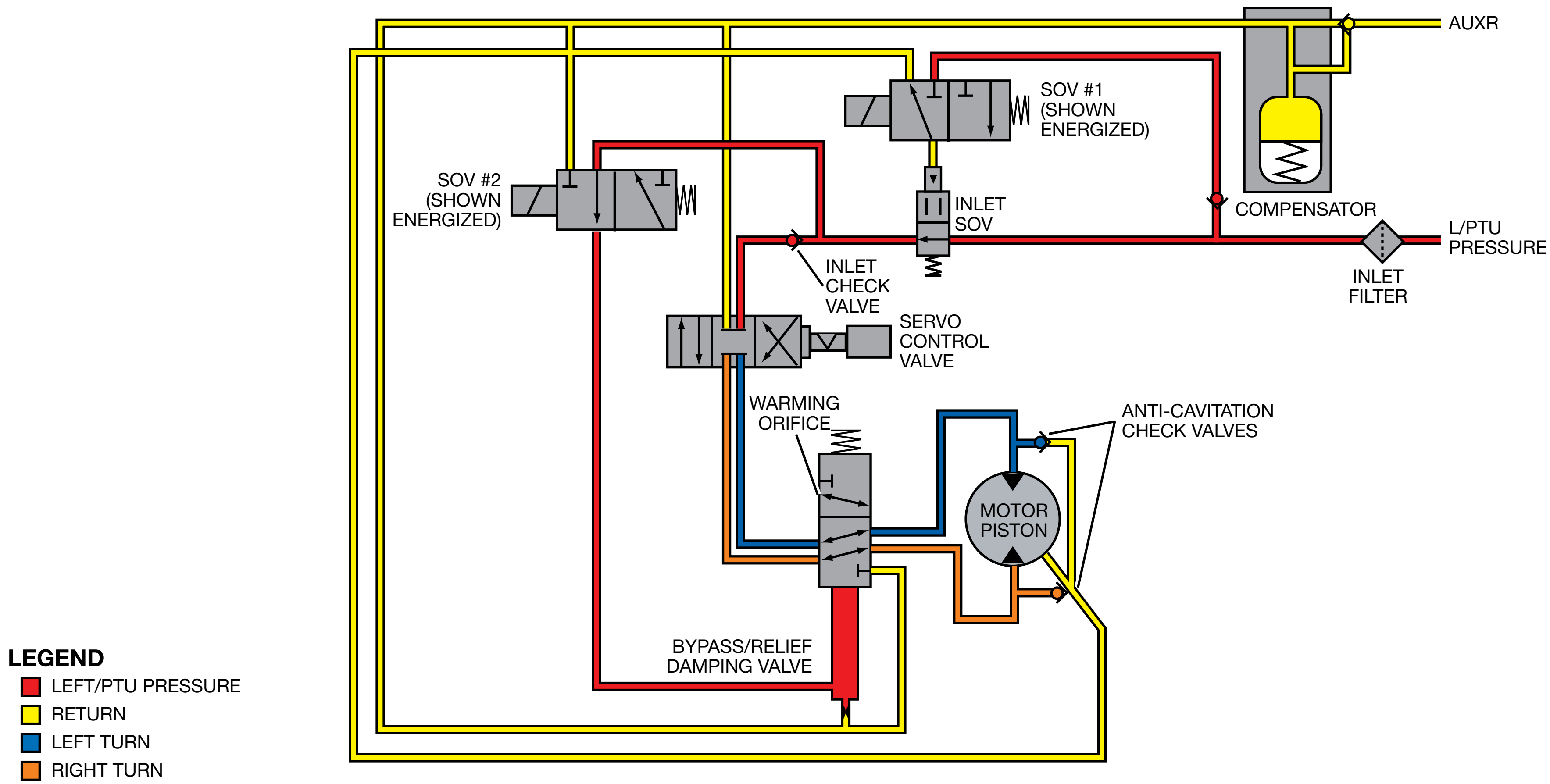


Figure 32-76. Hydraulic Actuator Functional Overview

NWS OPERATION

Normal Operation

In flight with steering power ON and the landing gear up, hydraulic pressure is applied to the hydraulic pressure-operated inlet shutoff valve in the steering unit (Figure 32-76). When the nose gear reaches the down-and locked position, the ECM electrically energizes the SOV No. 1, allowing hydraulic pressure to the EHV and to the SOV No, 2, As part of the BIT function, the ECM then commands the EHSV right and left, checking the LVDT and the EHSV for correct movement. This process takes approximately 500 milliseconds. If the EHSV is operational, it is driven to a position to provide warming flow through the warming orifice of the bypass valve and out through the compensator. Upon nose weight on wheels OR combined weight on wheels, the EHSV is centered. Upon nose weight on wheels AND combined weight on wheels, the SOV No. 2 is energized.

The ECM allows for bounce when the nosewheel touches down; it then energizes the SOV No. 2 and commands a straight-ahead signal to the nose wheel for 300 milliseconds. After the 300-millisecond delay, the nosewheel steering system is activated.

SOV No. 1 allows hydraulic pressure to the EHSV and SOV No. 2. When the SOV No. 2 is energized, it allows hydraulic pressure to the bypass/relief valve which will shift position, allowing pressure to the hydraulic motor. With pressure from the SOV No. 2 applied to the bypass/relief valve and pressure to the EHSV, the EHSV can control wheel movement. Both solenoid-operated valves (No. 1 and No. 2) are required for the nosewheel steering system to operate.

Normal operation of the nosewheel steering system can be in one of two modes. Variable Gain or Fixed Gain. During variable gain steering the ECM will vary the maximum allowable steering angle based on ground speed inputs from the IRUs. The higher the ground speed the lower the steering angle.

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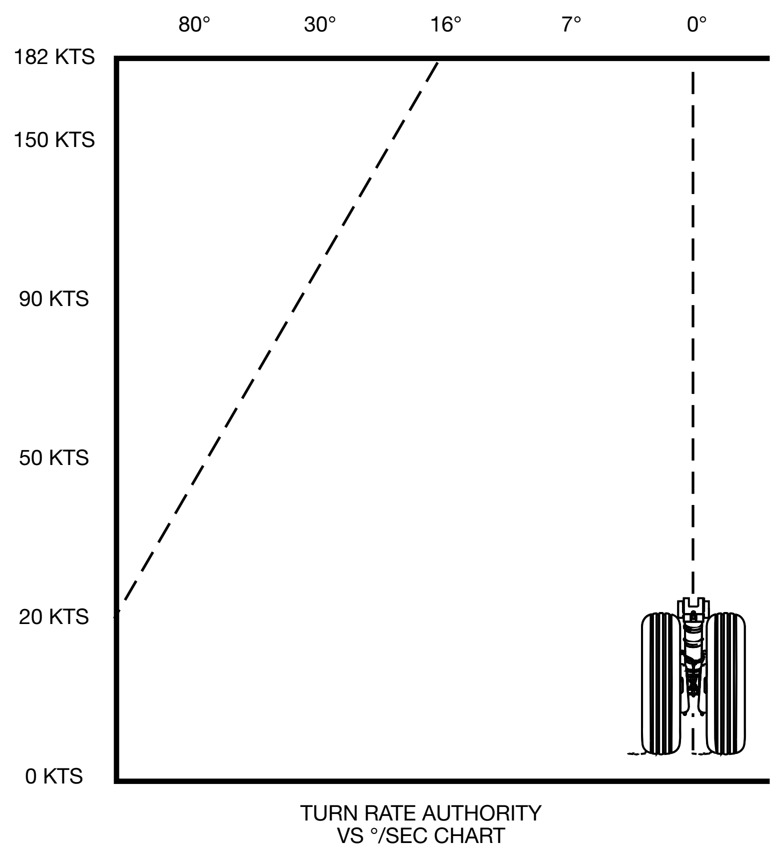

Figure 32-77. Nose Wheel Variable Gain

Variable Tiller Gain

Full tiller authority is available at ground speeds less than 12 knots. As speeds increase above 12 knots, the nose wheel angle is decreased for the same amount of tiller angle. At 12 knots of ground speed the tiller will deflect the nose wheel to a maximum of 80 degrees. Above 160 knots the nose wheel will not deflect more than 16 degrees with full tiller input left or right (Figure 32-77).

Fixed Gain Steering

Fix Gain steering occurs when IRS 1 and 2 are not able to provide the ECM with ground speed information. If this occurs, the steering system will be in a fix gain operation of 22° per second rate regardless of ground speed.

Degraded Mode

Certain failures are not hazardous to the aircraft. Depending on the type of failure detected, the ECM provides limited-capability operation while reporting the failure to the CMC and CAS (Table 32-3). The ECM operates in the degraded mode when there is a tiller failure or a rudder pedal RVDT failure.

If there is a tiller failure, the ECM will ignore the tiller signal and increase rudder pedal authority from 7° to 16°.

If there is a rudder pedal RVDT failure, the ECM will ignore rudder pedal input. All other capabilities of the system are preserved.

During degraded mode the steering system will always be in fixed gain operation.

Fail-Passive Mode

When the ECM detects a failure other than the RVDTs, it shuts down active steering by deenergizing the SOV No. 1 and the SOV No. 2 of the steering unit. This mode of operation is referred to as the “free castor / shimmy damping” mode. If the nosewheel steering system fails, the nosewheels castor, allowing steering by differential brake application. If the IRUs are not properly aligned the ECM will revert to fixed gain steering and the maximum steering angle will be 22° regardless of ground speed.

Figure 32-78. WOW Overview

WEIGHT ON WHEELS SYSTEM

WOW GENERAL

The landing gear Weight on Wheels (WOW) system provides air / ground status signals to various electrical and electronic equipment. The system consists of hermetically-sealed gold contact WOW switches, relays, and CAS monitoring. Both the nose gear WOW and the main landing gear WOW switches control various WOW system relays.

One WOW switch is mounted on the aft side of each main landing gear shock strut assembly. When the aircraft is on the ground a cam on the shock strut torque arm rotates to close the contacts of the WOW switch. In the case of the nose gear, the cam rotates to release the switch to its relaxed position when the aircraft is on the ground, and compresses the switch when in the air. WOW system relays and fault monitoring receive power from L/R essential and L EMER 28VDC busses (Figure 32-78).

WOW Monitor Warning Function

The Monitor Warn (MW) functions are used to monitor the signal integrity of the WOW system. Sixteen separate discrete inputs provide left, right, and nose switch status to the Modular Avionics Unit (MAU) I/O modules. Switch status of left WOW air and ground, right WOW air and ground, combined WOW air and ground, and nose WOW air and ground are provided to both Single Generic I/O (SGIO) 2 and SGIO 6. SGIO 2 is located in MAU 1 and operates from R ESS aircraft power while SGIO 6 is located in MAU 3 and operates from L ESS aircraft power. The MW function will compare these signals to independent internal computed air / ground inputs from the radar altimeter and air data system.

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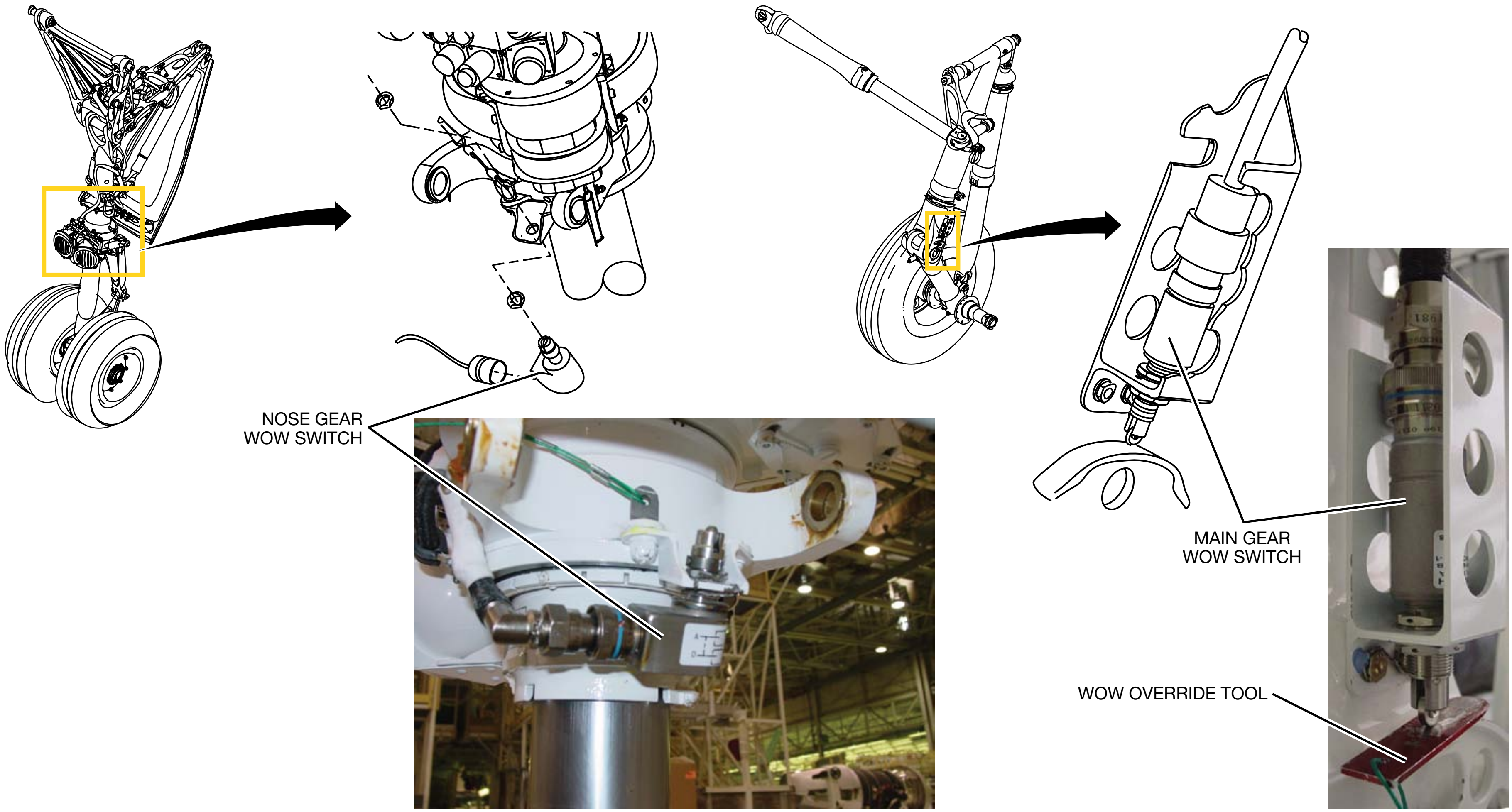

Figure 32-79. WOW Switches

WOW COMPONENTS

Nose Gear WOW Switches

One pole of the nose gear WOW switch is used for the nose WOW signals to CAS. The other pole of the nose WOW switch is utilized exclusively by the nose wheel steering system.

The nose gear WOW switch extends to indicate the ground mode and is compressed by the torque links to indicate the air mode. The main landing gear WOW switches are extended to indicate the air mode and compressed to indicate the ground mode (Figure 32-79).

The systems that use a combined WOW input are listed in the tables at the end of this section to evaluate the cumulative effects of all of these signals failing at the same time. For all of the combined WOW relays to fail in ground mode requires both the left and right WOW switches to fail simultaneously, which is extremely improbable. The effects of these failures are considered to be major because the cumulative effect can cause additional crew workload and increased risk of inadvertent ground spoiler or thrust reverser deployment. For all of the relays to fail in air mode, only one of the main gear WOW switches has to fail in the open position. The combined effects of this failure are considered minor.

Main Gear WOW Switches

The two main gear WOW switches are configured to provide the left main gear WOW, right main gear WOW, and combined left and right main gear WOW signals. One pole of the left main gear WOW switch is used for the exclusive left WOW signals and one pole of the right main gear WOW switch is used for the exclusive right WOW signals. The combined WOW signals are provided by a series connection of one pole of the left gear WOW switch and two poles of the right gear WOW switch.

The left WOW ground signal actuates a single relay used for thrust reverser, automatic ground spoiler deployment, and brake control and indication. The right WOW ground signal does the same. The combined WOW ground signal is used to trip multiple four-pole relays that are utilized by various aircraft systems requiring WOW input.

All WOW system relays are actuated by power from the essential and EMER bus. When the ground service bus is manually turned on while on the ground, the essential bus is not powered, so all WOW relays are relaxed in the air mode state. The remote fuel quantity system and engine oiler indicators are powered by the ground service bus. It is required that both of these systems be available only on the ground, and turned off in the air. To provide this, the combined air signal is used to trip a single ground service bus relay that is normally relaxed on the ground and actuated in the air. It is used to remove power from the remote fuel quantity system and engine oiler indicator while in the air.

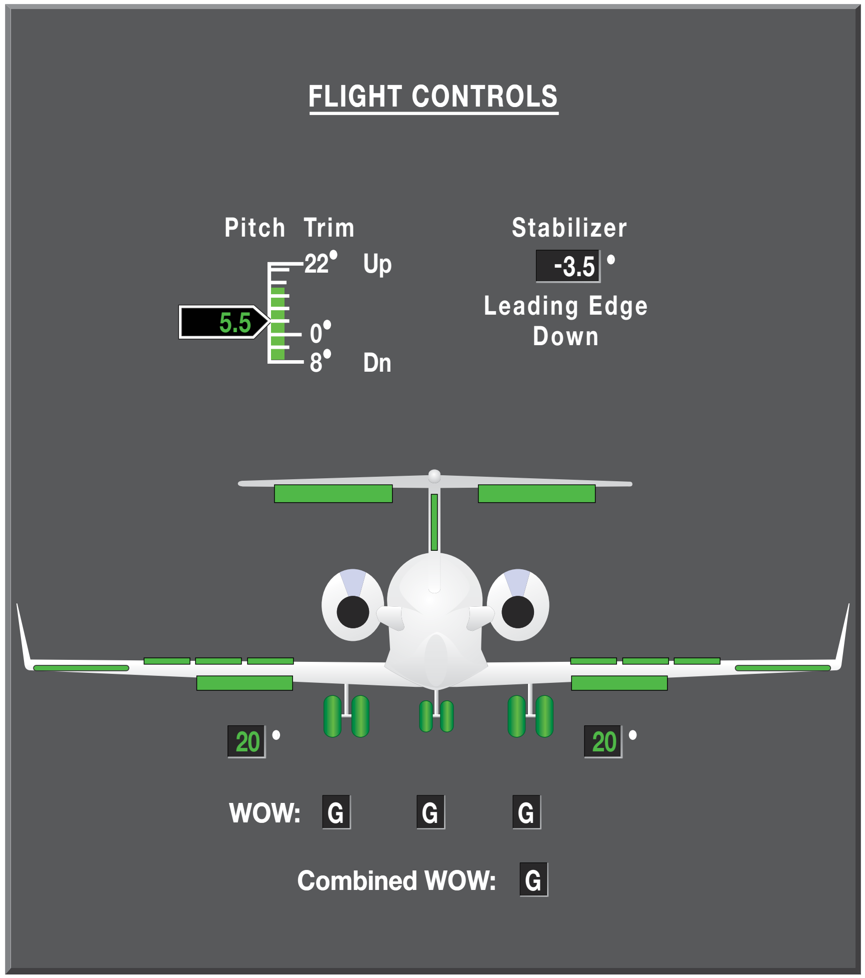

Figure 32-80. Flight Controls Synoptic Page

WOW INDICATIONS

WOW Display

WOW information is presented on the flight controls synoptic page (Figure 32-80 and Table 32-3). The present state of the left, right, and nose WOW signal is denoted by the letter A or G inside the appropriate landing gear wheel symbol. The present state of the Combined WOW is shown just below the three landing gear wheel symbols with the nomenclature combined WOW: G (or A). When the landing gear is retracted the landing gear wheel symbols are not shown, but the WOW state is still displayed in the same location. During a **WOW Fault**, the symbol (or symbols) (A or G) that triggered the fault is shown amber. This enables the pilot to determine which WOW signal is faulted.

- **WOW Fault**
- **WOW Fault**
- **WOW Power Fail**

Table 32-3. WOW CAS MESSAGES

MESSAGE	DESCRIPTION
WOW Fault	MW determines aircraft is in the AIR mode and the WOW switches are in the GROUND mode.
WOW Fault	MW determines aircraft is in the GROUND mode and the WOW switches are in the AIR mode, or a WOW system power failure.
WOW Power Fail	Loss of power to any WOW switch.

Weight On Wheels Faults

A "WOW Fault" CAS message is provided for any WOW signal disagreements between the current WOW switch position and Radio Altimeter (RA) / Air Data System (ADS) air / ground data (Table 32-3). There are two levels of severity for the "WOW Fault" message. Most of the WOW failures require no pilot action and will annunciate a blue **WOW Fault** message in CAS. A left and right WOW in the ground mode while airborne is a potentially critical WOW failure because it can lead to inadvertent automatic ground spoiler deployment during certain aircraft configurations. An airborne WOW miscompare will generate an amber **WOW Fault** CAS message. The pilot action would be to remove power from both the left and right WOW circuit breakers, causing the system relays to relax to the air mode.

WOW FAULT (Blue)

A blue **WOW Fault** message is illuminated anytime the MW function determines the aircraft air data system, calibrated air speed is less than 50 knots AND any WOW switch is in the air mode, or when radio altitude is greater than 147.5 feet Above Ground Level (AGL) and any WOW switch is in the ground mode. A blue **WOW Fault** message is also provided for WOW system power failures when input power is lost from L WOW, R WOW or combined WOW 28VDC sources. This message is not latched and will extinguish when the required parameters are no longer true.

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WOW FAULT (Amber)

An amber **WOW Fault** CAS message is illuminated and latched anytime the MW function determines the aircraft air data system CAS is greater than 60 knots, radio altitude is greater than 147.5 feet AGL and left and right WOW switches are in the ground mode. The amber **WOW Fault** message will reset when aircraft air data system CAS is less than 60 knots, or radio altitude is greater than 147.5 feet AGL and either left or right WOW switches are in the air mode. The flight crew must pull the left and right weight on wheel circuit breaker to prevent inadvertent ground spoiler or thrust reverser deployment in flight.

WOW POWER FAIL (Blue)

A blue **WOW Power Fail** CAS message warns of the loss of WOW power. The MW function determines this whenever both the air and ground signals from a WOW switch are not present. In this situation, WOW switch monitoring is lost and the affected WOW relays relax to the air mode.

The WOW initiated thrust reverser and automatic ground spoiler deployment would not be available during a left and / or right WOW power failure. The pilot action to this message would be to verify WOW circuit breakers are closed. The continuous monitoring of WOW power eliminates the need for any manual pilot initiated WOW test prior to landing. When the **WOW Power Fail** message is displayed, the blue **WOW Fault** CAS message is suppressed.

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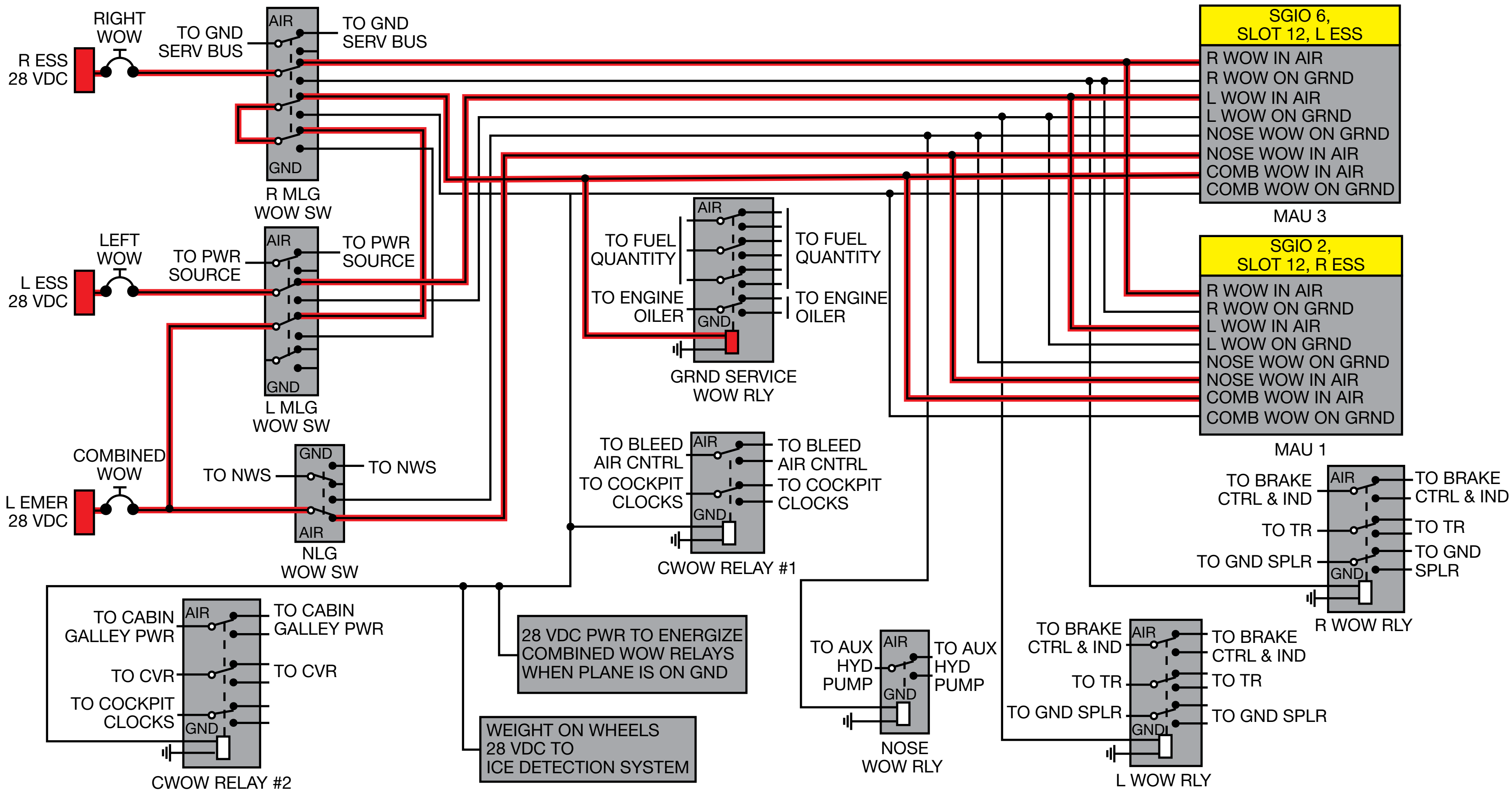

Figure 32-81. WOW Electrical Schematic

WOW OPERATIONS

Since the WOW system is composed of relays that are actuated on the ground and relaxed in the air, the WOW state is defaulted to the AIR mode in the event of a WOW Power Fail and shown in amber on the synoptic page. The loss of power to the relays causes them to relax, putting all contacts in the air mode (Figure 32-81).

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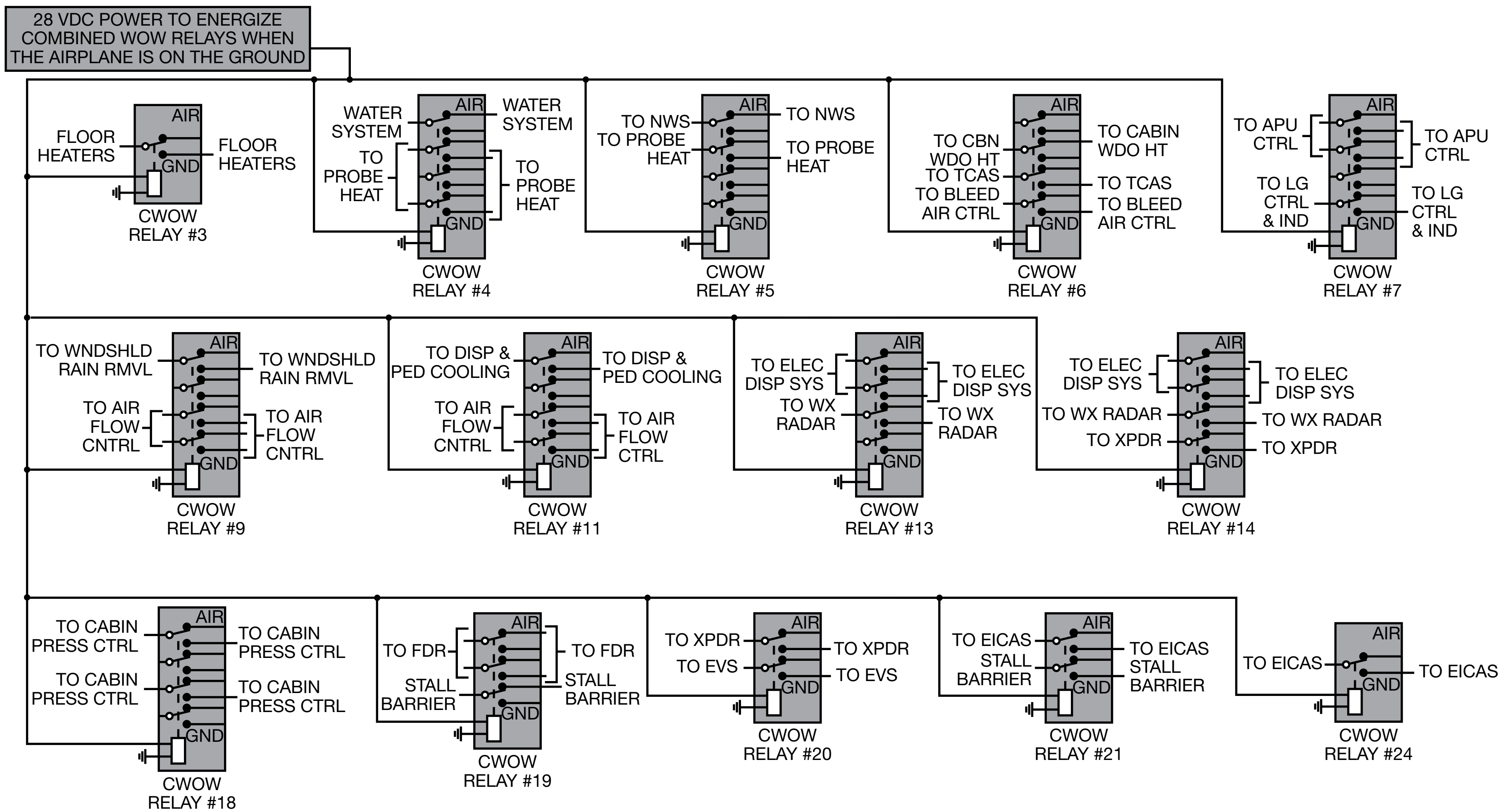

Figure 32-82. WOW Electrical Relay Schematic

Operations (Cont)

The unlikely condition where both the air and ground WOW signal are present at the same time will cause the generation of the **WOW Fault** message. The worst case of this situation is where the fault is caused by a hot short on the ground signal line while the aircraft is airborne. The WOW relays would remain actuated in the ground mode, leading to the concern about inadvertent automatic ground spoiler deployment. Therefore, the associated WOW symbol is defaulted to ground mode and shown in amber, to alert the pilot that the WOW relays may be in ground mode (Figure 32-82).

When a monitor warning function that processes the WOW signals is not functioning, an amber crosshatch is displayed in place of the A or G nomenclature (Table 32-4 to Table 32-7).

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Table 32-4. WOW INTERFACING SYSTEM INPUT AND EFFECT

INTERFACING SYSTEM	FUNCTION OF WOW INPUT	FAILURE EFFECT—FAILS IN AIR MODE	FAILURE EFFECT—FAILS IN GROUND MODE
AIR DATA COMPUTERS	Provide ground/air logic for startup modes.	Will perform warm start on ground.	Will perform cold start in air.
AIRFLOW CONTROL	Disable air-conditioning shut-off relays in air.	Packs will not automatically switch off for engine start.	Packs will automatically switch off for engine restart in air. May cause pressure bumps in cabin.
AIRFLOW CONTROL	Logic to air-conditioning controllers.	Memory will not log completion of flight leg for fault recording.	Memory will not log beginning of flight leg for fault recording.
APU CONTROL	Prevent APU shutoff when aircraft is in air. This is considered the essential mode for the APU.	APU will ignore operating parameters that would normally cause a shut down of the APU on the ground.	APU will shut off when operating anomolies occur.
APU CONTROL	Switch APU oil heater power source.	APU oil heater will not operate until there is power on the main AC bus.	APU oil heater will use the essential AC bus as the power source.
APU CONTROL	APU ECU logic.	There will be little or no effect on APU operation.	The APU may have difficulty starting or may not start because settings (such as APU inlet door position) will be set for ground mode.
APU FIRE DETECTION	Enable speaker amplifier on ground.	Speaker will not produce fire warning tone on ground.	Wheel well speaker will emit tone in air.
AUTOFLIGHT CONTROL	Provide ground/air logic for autopilot function.	Autopilot can be selected ON while aircraft is on ground.	Autopilot cannot be selected.
BLEED-AIR CONTROL	Provide ground/air logic to bleed-air controller.	Memory will not log completion of flight leg for fault recording.	Memory will not log completion of flight leg for fault recording.

Table 32–4. WOW INTERFACING SYSTEM INPUT AND EFFECT (Cont)

INTERFACING SYSTEM	FUNCTION OF WOW INPUT	FAILURE EFFECT— FAILS IN AIR MODE	FAILURE EFFECT— FAILS IN GROUND MODE
BLEED-AIR ISOLATION	Allow APU bleed-air switch to open bleed-air isolation valve on ground.	APU bleed-air isolation switch will not open bleed-air ilsolation valve.	Bleed-air isolation valve can open in air if APU bleed-air switch is selected ON.
CABIN GALLEY POWER	Energize load-shed relay with only one power source while in air.	Will shut off galley power on ground when only one main power source is available.	Galley power will not shut off automatically when only one power source is available.
CABIN PRESSURE CONTROL	Provide ground / air logic to cabin pressure controller.	Memory will not log completion of flight leg for fault recording.	Memory will not log beginning of flight leg for fault recording.
COCKPIT CLOCKS	Initiate flight time mode.	Clocks will continue counting air time.	Clocks will not start counting air time.
COCKPIT VOICE RECORDER	Enable bulk erase.	Bulk erase will not operate.	Bulk erase will operate if initiated by flight crew.
EICAS	Provide ground / air logic for startup modes.	Will perform warm start on ground. Not all self-test functions are utilized.	Will perform cold start in air. Will temporarily prevent display on EICAS.
EICAS	Provide weight-on-wheels logic to 429 data bus.	Improper logic on 429 bus. FADECs and other systems can read wrong state. Will not cause any critical failures.	Improper logic on 429 bus. FADECs and other systems can read wrong state. Will not cause any critical failures.
EICAS	Provide ground / air logic for startup modes.	Will not provide maintenance displays on ground.	Maintenance displays will be provided in air.
ELECTRONIC DISPLAY SYSTEM	Provide ground / air logic for startup modes.	Will perform wrm start on ground. Not all self-test functions are utilized.	Will perform cold start in air. Will temporarily prevent display of information on displays.

Table 32-5. WOW INTERFACING SYSTEM INPUT AND EFFECT—LEFT AND RIGHT WOW INPUTS

INTERFACING SYSTEM	FUNCTION OF WOW INPUT	FAILURE EFFECT— FAILS IN AIR MODE	FAILURE EFFECT— FAILS IN GROUND MODE
THRUST REVERSER	Provide WOW input to enable thrust reversers on ground.	Thrust reversers will not get a WOW signal to enable deployment.	There is a loss of one of the safety mechanisms to prevent inadvertent thrust reverser deployment in air.
BRAKE CONTROL AND INDICATION	Provided WOW input to the antiskid electronic controller for touchdown protection if IRS circuit is not available.	Touchdown protection circuitry will not transition to ground mode. Touchdown protection will inhibit braking until wheel speed signals are present.	Touchdown protection is lost if IRS is not available.
GROUND SPOILERS	Provide WOW input to enable ground spoilers on ground.	Ground spoilers will not get a wow signal to enable deployment.	There is a loss of one of the safety mechanisms to prevent inadvertent ground spoiler deployment in air.

Table 32-6. WOW INTERFACING SYSTEM INPUT AND EFFECT—GROUND SERVICE WOW INPUTS

INTERFACING SYSTEM	FUNCTION OF WOW INPUT	FAILURE EFFECT— FAILS IN AIR MODE	FAILURE EFFECT— FAILS IN GROUND MODE
ENGINE OILER	Control power to oiler control panel.	Will not be able to turn on oiler control panel or refill oil from panel.	The oiler control panel will be powered in flight. There is no effect on aircraft operation.
FUEL QUANTITY	Control panel to ground service panel.	Ground service panel will not be powered.	Ground service panel will be powered in flight. There is no effect on aircraft operation.
FUEL QUANTITY	Ground / air status input to signal conditioners.	Fuel quantity system will use the in-air algorithm for calculating fuel quantity. May have negligible errors in fuel quantity.	Fuel quantity system will use the on-ground algorithm for calculating fuel quantity. May have negligible errors in fuel quantity.

Table 32-7. COMBINED WEIGHT ON WHEELS RELAYS

COMBINED RELAY	DESCRIPTION
1	Bleed Air Control, Cockpit Clocks, Cabin Window Heat, Landing Gear Control and Indication
2	Galley Power, Cockpit Voice Recorder, Cockpit Clocks
3	Reserved for Future Use
4	Probe Heat, Water System
5	Nose Wheel Steering, Probe Heat
6	Cabin Window Heat, TCAS, Bleed Air Control
7	APU Control, Landing Gear Control and Indication
8	(Not Installed)
9	Windshield Rain Removal Blower, Air Flow Control
10	(Not Installed)
11	Equipment Cooling, Air Flow Control
12	(Not Installed)
13	Electronic Display System, Weather Radar
14	Electronic Display System, Weather Radar, Transponder
15	(Not Installed)
16	(Not Installed)
17	(Not Installed)
18	Cabin Pressure Control
19	Flight Data Recorder, Stall Barrier
20	Transponder, Enhanced Vision System
21	Engine Indicating/Crew Alerting System, Stall Barrier
22	Not Installed)
23	Not Installed)
24	Engine Indicating/Crew Alerting System